33RD BLED ECONFERENCE

ENABLING TECHNOLOGY FOR A SUSTAINABLE SOCIETY

JUNE 28 – 29, 2020, ONLINE

CONFERENCE PROCEEDINGS

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University of Maribor Press

Faculty of Organizational Sciences

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Anand Sheombar
Doroteja Vidmar

June 2020

Title *Naslov*
33rd Bled eConference – Enabling Technology for a Sustainable Society

Subtitle *Podnaslov*
June 28 – 29, 2020, Online Conference Proceedings

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Graphics material
Grafične priloge

Authors

Conference
Konferenca

33rd Bled eConference - Enabling Technology for a Sustainable Society

Location and date
Kraj in datum

Online, June 28 –29, 2020

Publihed by
University of Maribor
University Press
Slomškov trg 15, 2000 Maribor, Slovenia
https://press.um.si, zalozba@um.si

Co-published by
University of Maribor
Faculty of Organizational Sciences
Kidričeva cesta 55a, 4000 Kranj, Slovenia
http://www.fov.um.si, dekanat.fov@um.si

Edition 1ST

Publication type E-book

Available at https://press.um.si/index.php/ump/catalog/book/483

Published Maribor, June 2020

CIP - Kataložni zapis o publikaciji
Univerzitetna knjižnica Maribor

502.131.1:331.101.52(082)(0.034.2)

BLED eConference Enabling Technology for a Sustainable Society (33 ; 2020 ; online)
33rd Bled eConference Enabling Technology for a Sustainable Society [Elektronski vir] : June 28 - 29, 2020, online : conference proceedings / editors Andreja Pucihar ... [et al.]. - 1st ed. - E-zbornik. - Maribor : University Press, 2020

Način dostopa (URL): https://press.um.si/index.php/ump/catalog/book/483
ISBN 978-961-286-362-3 (pdf)
doi: 10.18690/978-961-286-362-3
1. Gl. stv. nasl. 2. Pucihar, Andreja
COBISS.SI-ID 19707139

ISBN 978-961-286-362-3 (pdf)

DOI https://doi.org/10.18690/978-961-286-362-3

Price / *Cena* Free copie

For publisher / *Odgovorna oseba založnika* full prof. Zdravko Kačič, PhD
Rector, University of Maribor

33RD BLED ECONFERENCE ENABLING TECHNOLOGY FOR A SUSTAINABLE SOCIETY

ANDREJA PUCIHAR[1] (ET AL.)

[1]PhD, Program Committee Chair, 33rd Bled eConference, Professor, University of Maribor, Faculty of Organizational Sciences, Kranj, Slovenia, e-mail: andreja.pucihar@um.si

Abstract Bled eConference, organized by University of Maribor, Faculty of Organizational Sciences, has been shaping electronic interactions since 1988. Bled eConference is the oldest, most traditional, and well-renowned conference in the field with a tradition of more than 30 years. In 2020, Bled eConference was held online due to the COVID-19 pandemic for the first time. The role of digital technologies has never been as important as at this time, enabling people to interact and work from home during the quarantine. The theme of this year's 33rd conference is "Enabling Technology for a Sustainable Society". In the context of digital society, the implementation of digital technologies to achieve higher efficiency and competitive advantage is insufficient. Society calls for different economic models; more responsible, righteous, less exploitative to achieve the wellbeing and sustainable development of society. Digital technologies have an important role in achieving these goals. We address various aspects of digital transformation opportunities and challenges. We provide directions and guidelines for organizations to meet and overcome challenges on their way towards sustainable business models. Themes covered in proceedings focus on: business model innovation; data science; e-health, digital wellness; new applications, organizational models; approaches and cases for education in the digital economy.

Keywords: digital transformation, digital technology, innovation, digitalization, sustainability.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3
ISBN 978-961-286-362-3

University of Maribor Press

Table of Contents

DOCTORAL CONSORTIUM

DISRUPTIVE INNOVATIONS IN ELECTRONIC TRANSPORTATION MANAGEMENT SYSTEMS

MARIJA JOVIĆ[1], EDVARD TIJAN[1], SAŠA AKSENTIJEVIĆ[2] & DRAŽEN ŽGALJIĆ[1]

[1] University of Rijeka, Faculty of Maritime Studies, Rijeka, Croatia, e-mail: jovic@pfri.hr, etijan@pfri.hr, zgaljic@pfri.hr
[2] Aksentijević Forensics and Consulting, Ltd., Viškovo, Croatia, e-mail: sasa.aksentijevic@gmail.com

Abstract This paper provides an overview of selected disruptive innovations (Blockchain, Internet of Things and Big Data) in electronic transportation management systems in general, and their possible impact in maritime transport. The theoretical background is provided, including transportation, electronic transportation management systems and selected disruptive technologies. The impact, major challenges and success factors in implementing disruptive innovations in maritime transport are pointed out and elaborated. Finally, authors provide the discussion and the future perspective of selected disruptive innovations, with an emphasis on maritime transport.

Keywords: disruptive innovations, maritime transport, blockchain, internet of things, big data.

Univerzitetna založba Univerze v Mariboru

DOI https://doi.org/10.18690/978-961-286-362-3.1
ISBN 978-961-286-362-3

1 Introduction

The effective transportation management systems should provide an optimal route with recommended optimized non - work stops (Nimchuk & Mckinney, 2018). However, not all participants are taking advantage of the vast benefits a transportation management system provides (Cerasis, 2016). According to (Dreßler, Beißert, Beyhoff, & Wirtz, 2016), each participant organizes his own transport processes without informing other participants, even though the smooth transportation flow largely depends on communication. Numerous transport issues exist such as traffic congestions, redundant administration and loss of time due to unnecessary waiting (Marija Jović, Tijan, Aksentijević, & Sotošek, 2019). According to (Tijan, Agatić, Jović, & Aksentijević, 2019), various stakeholders are still faced with a tedious task of producing and distributing paper documents to numerous administrative authorities.

Disruptive innovations may play an important role in electronic transportation management systems (e-TMS) and in improving transport business. According to (F. Ullah, Sepasgozar, & Wang, 2018) "Disruptive innovations are initially characterized by significant limitations compared with existing technologies but have the potential for dramatic improvements in efficiency, cost reduction or other highly significant benefits".

This article focuses on the following research question: What is the role of disruptive innovations in electronic transportation management systems? Based on the literature review and the experience in planning, execution and follow up of several projects related to digitalization in transport, the authors of this paper have singled out the following disruptive innovations: Blockchain, Internet of Things (IoT) and Big Data.

Blockchain technology is a potential solution to numerous problems such as: insufficient availability of cargo monitoring and lack of transparency (resulting from poor data handling (Marija Jović, Filipović, Tijan, & Jardas, 2019). Furthermore, advanced "digital" seaports such as port of Rotterdam are the proof of the profitability of IoT applications and the successful monitoring of digitalized business processes (M Jović, Tijan, Aksentijević, & Čišić, 2019). Another disruptive technology Big Data is also increasingly present in the transport, in terms of:

operations (enabling ship owners to determine the optimum speed, thus affecting fuel consumption), voyage operations, tracking or monitoring (Marx, Gebhard, Jović, & Tijan, 2019).

A lack of research and scientific papers dealing with disruptive innovations in maritime transport is pronounced. To overcome this research gap, the authors conducted the review of available literature and sources.

The goal of the research is to point out the importance of selected disruptive innovations in electronic transportation management systems (with an emphasis on maritime transport). Transparency and easy access to data are the basis for successful transport business. Therefore, the research problem stems from increased costs and lost time due to the archaic procedures and inadequate execution and monitoring of business processes in transport.

This paper presents a review of research papers and other sources (such as official webpages of seaports, seaport stakeholders and maritime transport enterprises), providing a better understanding of disruptive innovations in electronic transportation management systems.

2 Background

Transportation is a multimodal, multi-problem and multi-spectral system, as it involves different categories and activities, such as policy-making, planning, designing, infrastructure construction and development (Almasi, Sadollah, Kang, & Karim, 2016). Transportation involves interconnected stakeholders who have to exchange documents in order to execute and complete transport services (Tijan, Jović, Jardas, & Gulić, 2019).

A Transportation Management System (TMS) is a platform that is designed to streamline the shipping process (Freightquote by C.H. Robinson, 2019). Transportation Management Systems assist in managing certain aspects of the transportation process (AQT Solutions, 2019):

1. Planning and decision making – TMS will define the most efficient transport schemes according to given parameters.
2. Transportation Execution – TMS will allow for the execution of the transportation plan such as carrier rate acceptance, carrier dispatching, electronic data interchange (EDI.
3. Transport follow-up – TMS will allow following any physical or administrative operation regarding transportation: custom clearance, invoicing and booking documents, sending of transport alerts (delay, accident, non-forecast stops…).

Transportation Management Systems still have some shortcomings such as (Xu, Zhen, Li, & Yue, 2017), (Sigfox, 2020):

1. The monitoring information is confined to the positioning and geographical information of the goods or vehicles without the physical status sensing during the transport procedure.
2. Numerous Transportation Management Systems lack a uniform data transferring capability and storage format to achieve data sharing and integration functionalities.
3. Using of "obsolete" RFID technologies in Transportation Management System: although RFID tags help track goods as they arrive at each destination, they give no information about what happens in between.

As the goal of the research is to point out the importance of selected disruptive innovations in electronic transportation management systems (focused on maritime transport), it is necessary to define the term "disruptive innovative technologies". Despite different perspectives among entrepreneurs, academics and policy makers, innovations are defined broadly as the development and use of new ideas and behaviors in organizations and narrowly as implemented technologically new products and processes or significant technological improvements in products and processes (Majamäki & Akpinar, 2014a). Disruptive technologies, a term coined by Professor Clayton Christensen and colleagues, are defined as a set of technologies that displaces the existing methods or technologies and shakes up the industry to open new avenues for innovation and business development (F. Ullah et al., 2018), (Hongdao, Bibi, Khan, Ardito, & Khaskheli, 2019).

Maritime transport is the main mode of transport in global trade and one of the cornerstones of globalization (Halim, Kirstein, Merk, & Martinez, 2018). (Sanchez-Gonzalez, Díaz-Gutiérrez, Leo, & Núñez-Rivas, 2019) categorized the use of the latest digital technologies in maritime transport in the eight domains: autonomous vehicles and robotics; artificial intelligence (AI); Big Data; virtual reality, augmented and mixed reality; internet of things; the cloud and edge computing; digital security; and 3D printing and additive engineering. According to their research, the most widely studied domains are robotics, artificial intelligence and Big Data, especially unmanned vehicles in robotics and the use of artificial intelligence as a means of supporting vessels aids for navigation.

The concept of Big Data comes with a set of related components that enable organizations to put the data to practical use and solve several business problems. These include the IT infrastructure needed to support Big Data; the analytics applied to the data; technologies needed for Big Data projects; related skill sets; and the actual use cases that make sense for Big Data (Kobielus, 2018).

The Blockchain technology is based on a method where previously unknown parties can jointly generate and maintain practically any database on a fully distributed basis where transaction correctness and completeness are validated using consensus of independent verifiers (Tijan, Aksentijević, Ivanić, & Jardas, 2019). In the shipping industry, Blockchain was initially used to enable confidential financial transactions between the stakeholders, without relying on "third parties".

Internet of Things (IoT) is also considered as one of the disruptive technologies and has attracted lots of research attention in the recent past (I. Ullah, Ahmad, Mehmood, & Kim, 2019), (I. Ullah, Ahmad, & Kim, 2018), (Sánchez, Álvarez, Antolinos, Fernández, & Iborra, 2018). Furthermore, the continued development of the IoT, which will ultimately connect people, processes and data into wide-scale networks, could affect how transportation services are provided (Texas A&M Transportation Institute, 2016).

3 Research methodology

Based on the literature review and authors' experience in several commercial and scientific projects related to digitalization in transport, authors have singled out and analyzed the following selected disruptive technologies in transport: Blockchain, Big Data and Internet of Things. The aforementioned projects are DigLogs - Digitalising Logistics processes (University of Rijeka, Faculty of Maritime Studies, 2019a), Electronic Transportation Management System - e-TMS (University of Rijeka, Faculty of Maritime Studies, 2019b), and Information management in seaport clusters (University of Rijeka Faculty of Maritime Studies, 2017), etc.

Blockchain technology is a potential solution to numerous problems in maritime transport such as: insufficient availability of cargo monitoring (maritime transport involves many stakeholders) and lack of transparency (resulting from poor data handling), relying on paperwork in 21st century (Marija Jović, Filipović, et al., 2019). Furthermore, Big Data and its analyses provide deep understanding of causalities and correlations in maritime transport, improving decision making (Marx et al., 2019). Internet of things, as another innovation, facilitates planning and management of business processes by implementation of modern information technologies (M Jović et al., 2019).

The authors started with the inclusion criteria by using a combination of keywords connected with logical operators - "disruptive innovations and transportation management system" and alternative keywords transportation management system" and "disruptive innovations and maritime transport" (title, abstract and keywords). Web of Science, Google Scholar, ResearchGate and SpringerLink's databases were used for this purpose. The search for articles was conducted according to the set time limitations (2014-2020) and mostly included journal articles and conference papers. To ensure that possible useful findings from various fields were not excluded, the authors did not limit the queries to a specific field or index.

A total of 66 sources have been identified, including 18 sources related to the challenges and success factors in pursuing disruptive innovations and 19 sources related to the impact of disruptive technologies on electronic transportation management systems.

The importance of the disruptive innovations is demonstrated in the paper through the analysis of several cases as well, such as: Port of Rotterdam, the partnership between Maersk and IBM; the partnership between port of Veracruz, Mexico and blockchain logistics company dexFreight etc.

4 Results

In this chapter, authors have analyzed the challenges and success factors in pursuing disruptive innovations, as well as the impact of disruptive technologies on electronic transportation management systems.

4.1 Challenges and success factors in pursuing disruptive innovations

Variety of transportation systems exist, including land transportation (road, rail, and maglev), aviation (airplanes, rockets), maritime (ferries, ships, ports), and pipeline (tunneling, risers, Hyperloop) (Kaewunruen, Sussman, & Matsumoto, 2016). Because of the different priorities of key stakeholders (carriers, shipping companies, agencies) involved in transport management, different technologies are needed for a specific business area. Furthermore, with the emergence of disruptive digital technologies, companies are facing unprecedented challenges and opportunities (May & Kiritsis, 2019).

Disruptive innovations, including Blockchain, Big Data and Internet of Things, in maritime transport faces certain challenges or risks which should be minimized in order to fully exploit their advantages. Table 1 enumerates the challenges in pursuing disruptive innovations, grouped by disruptive technologies in general and by selected disruptive technologies: Internet of Things, Blockchain and Big Data.

Table 1: Challenges in pursuing disruptive innovations

	Challenges	**Author(s)**
Disruptive technologies in general	Integrating and exploiting new digital technologies (at the level of the company)	(Hess, Benlian, Matt, & Wiesböck, 2016)
	Anticipating the business logic within formerly unknown markets	(Amshoff, Dülme, Echterfeld, & Gausemeier, 2015)
	Identifying disruptive innovations that have market potential, obtaining adequate funding at initial stages of the business, marketing of the disruptive innovation, the length and riskiness of the process	(Majamäki & Akpinar, 2014b)
	The firms' inability to adopt to new innovations	(Gemici & Alpkan, 2015)
Blockchain as a disruptive technology	Blockchain technology immaturity, no single underlying standard, concepts are difficult to be mastered and there is a need for programming intervention even in the simplest forms of implementation	(Tijan, Aksentijević, Ivanić, & Jardas, 2019)
	The lack of regulation (some facets of smart contract technology might be adopted by the logistics market, just to be overregulated, or even to be considered illegal)	(Gatteschi, Lamberti, Demartini, Pranteda, & Santamaría, 2018)
	Distributed trust and therefore security and privacy are the core of the Blockchain technologies, and have the potential to either make Blockchain technologies a success or cause them to fail	(Karame & Capkun, 2018)
Internet of Things as a disruptive technology	Security challenges; possible attacks on devices (IoT), confidentiality of information would be compromised in ports, i.e. business processes or designs that are key for the competitiveness of the port itself	("IT: The Biggest Threats to Digital Security for Business

		According to the Experts | Kiandra IT," 2018)
	Governments and companies cannot agree upon a definition what is an authorized data access.	(M Jović et al., 2019)
	Connecting things to the Internet is based on an IP network, and if its security is not closely monitored, the entire IoT network can be compromised.	(Gamundani, 2015)
Big Data as a disruptive technology	Big Data challenges may include capturing data, data storage, data analysis, search, sharing, transfer, visualization, querying, updating and information privacy.	(Kotlarsky, Oshri, & Willcocks, 2018)
	Competitive conditions are not perfectly established or organized; what is allowed and not allowed has to be determined and respected by all involved players	(Trelleborg Marine Systems, 2018), (Koga, 2015)
	The more affordable, sophisticated or high-performance tools are necessary	(Rødseth, Perera, & Mo, 2016), (Windward, 2014), (Koga, 2015)
	Lack of qualified labor force	(Mammadova & Jabrayilova, 2017), (Koga, 2015)

Main cause of the firms' inability to become adapted to new innovations (Gemici & Alpkan, 2015) is the fact that when disruptive technologies emerge, many leading firms that have been successful in excelling at sustaining innovation, found themselves on the threshold of a new and harsh competition they are not familiar with. In order to overcome these challenges, important success factors that need to be taken into consideration are: clear vision and goals; identifying disruptive innovations that have market potential; obtaining adequate funding at initial stages of the business (Majamäki & Akpinar, 2014b).

According to (Karame & Capkun, 2018), distributed trust and therefore security and privacy are at the core of the Blockchain technologies, and have the potential to either make them a success or cause them to fail. In this respect, personal data, and sensitive data in general, should not be trusted in the hands of third-parties, where they are susceptible to attacks and misuse (Zyskind, Nathan, & Sandy' Pentland, 2015). Instead, users should own and control their data without compromising security or limiting companies' and authorities' ability to provide personalized services. One of the solutions is a platform which will combine a Blockchain, re-purposed as an access-control moderator, with an off-Blockchain storage solution (Laurent, Kaaniche, Le, & Vander Plaetse, 2018).

As previously mentioned, connecting things to the Internet is based on an IP network and if its security is not closely monitored, the entire IoT network can be compromised (Gamundani, 2015). Therefore, the security needs to be controlled from the very start, in the stage of making a "device connection", but it is also essential to include the "monitoring" phase coming after the implementation because of new and emerging forms of threats (M Jović et al., 2019).

4.2 The impact of disruptive technologies on electronic transportation management systems

Broadly speaking, disruption provides a solid ground for digital transformation and is becoming a prime objective for industries across the world, since it leads to the implementation of novel business and delivery models by allowing various forms of co-operation between companies, employees, and customers (Hongdao et al., 2019).

Significant advances in transportation technology are often triggered by sudden disruptive changes in technological capabilities. Table 2 shows the possible impacts of disruptive technologies in general as well as the impact of Internet of Things, Blockchain and Big Data (as disruptive technologies) on electronic transportation management systems. Later, the analysis of their impact is made, using a set of real cases.

Table 2: The impact of disruptive technologies

	The impact	**Author(s)**
Disruptive technologies in general	Disruptive technologies lead to a severe shift in value-creation networks giving rise to new market segments.	(Amshoff et al., 2015)
	The rapid development and adoption of the Internet and digital technologies increasingly changed business processes, leading to a disruptive digital transformation of the global industrial value chain	(Savastano, Amendola, Bellini, & D'Ascenzo, 2019)
	Disruptive technologies are initially characterized by significant limitations compared with existing technologies, but have the potential for dramatic improvements in efficiency, cost reduction or other highly significant benefits.	(Brackin, Jackson, Leyshon, & Morley, 2019)
Internet of Things as a disruptive technology	Automatic traffic routing based on the real-time information of conditions of traffic (rail, road, air, water) congestion and yard occupancy	(Aksentijević Forensics and Consulting Ltd., 2019)
	IoT could affect how transportation services are provided	(Texas A&M Transportation Institute, 2016)
	Ability to automatically react to the anomalies in order to prevent traffic congestion and waiting times	(Aksentijević Forensics and Consulting Ltd., 2019)
	Better planning of deliveries based on the real-time and predicted traffic conditions	(Aksentijević Forensics and Consulting Ltd., 2019)
	Connectivity to upcoming new communication standard like v2v (vehicle to vehicle) and v2i (vehicle to infrastructure) for peer-to-peer (p2p) real-time information gathering	(Aksentijević Forensics and Consulting Ltd., 2019)
	Integration of autonomous driving (robotic) solutions in the restricted environment (port community) for traffic optimization	(Aksentijević Forensics and Consulting Ltd., 2019)

Internet od Things and Decision Support Systems	Port operators and administration can better mitigate the environmental impact of logistic operations and take appropriate measures to correct or even prevent unwanted situations	(World Port Sustainability Program, 2019)
	The possibility to predict unwanted environmental conditions based on the machine learning of data from the past, meteorological forecasts and port traffic estimates for the future	(World Port Sustainability Program, 2019)
	Acquired data may be also reused as a trigger to handle other operations and activities in the port communities, which will streamline the operations and at the same time diminish the peek burden and impact on environment and local community	(World Port Sustainability Program, 2019)
	Allow transactions between companies to simplify, facilitate interfirm collaboration, increase trust among partners, and decrease costs of transactions in many industries	(Gausdal, Czachorowski, & Solesvik, 2018)
Internet of Things and Blockchain	The integration allows stakeholders to securely communicate, collaborate, and transact without human intervention and brings productivity and efficiency in the business.	(Hossain, 2018)
	More transparent, efficient, and secure monitoring of variables such as air and water pollution	(Bublitz et al., 2019)
Big Data	Can be used for improved predictions of arrival times and calculations of the needed speed	(Marx et al., 2019)
	Can bring advantages to the maritime transport sector regarding efficient routing, operation optimization and safety improvements	(Marx et al., 2019)
Big Data and Internet of Things	Optimization of movement of cargo manipulation machinery based on real-time, IoT and Big Data based information	(Aksentijević Forensics and Consulting Ltd., 2019)

IoT applications in shipping vary from route optimization to maintenance and smart cargo storage (Aksentijević Forensics and Consulting Ltd., 2019). One of the best real-life cases of usage of IoT technology is Port of Rotterdam, where there is in place a system for collecting data regarding ships in dock, cranes in the yard and individual containers. The port's operators now have greater transparency, better

prediction of estimated time of arrival and completion of operations than any other shipping hub in the world, helping them to move 25-50% more containers per hour than any other of its competitors in region (Riviera Maritime Media, 2018).

In the previous research regarding the electronic transportation management systems (Marija Jović, Tijan, et al., 2019), authors demonstrated the importance of electronic exchange of maritime cargo documents through the case of "Bill of Lading" (BL). BL is one of the most important documents in the transportation sector. According to (Dr Wu, Starr, & Tan, 2017), three main problems associated with the paper-based BL are:

1. Delays: Ships frequently arrive at the discharge ports before the paper BL as the paper BL has to be transported from party to party usually using the courier service. The non-availability of the paper BL at the discharge port means that the cargo cannot be delivered.

2. Costs: The cost of issuing and managing paper BLs, Letters of Indemnity (LOI), and other paper documents are estimated to constitute upwards of 15% of the physical transportation costs. When electronic BLs are used, the requirement for LOIs is reduced by some 90% (Dr Wu et al., 2017). This means a huge reduction in costs for the participants involved.

3. Security risks: Paper BLs are easily misplaced, stolen or lost. Again, when a paper-form BL is missing, the carrier often agrees to deliver the cargo against a LOI or a bank guarantee. The carrier, however, remains responsible for mis-delivery claims under forged BLs and stolen BLs.

The following case proves the importance of disruptive innovations in electronic transportation management systems, considering BL: in August 2018, the first ever container processed with the revolutionary new Blockchain-based CargoX Smart Bill of Lading™ was released in the port of Koper, Slovenia. The Bill of Lading for this shipment has been issued electronically and transferred with the help of an ultra-secure and reliable public Blockchain network in just minutes instead of days or weeks, and the chances of loss, theft or damage to the Bill of Lading have been dramatically reduced to near-zero (Marine Insight, 2019).

In another research "Economic and ecological aspects of electronic Transportation Management Systems in seaports" (Tijan, Jović, & Karanikić, 2019), authors have focused on Port Community System. Blockchain technology applied to port management will make it possible to store and share information on ship loads, improve financial operations and contracts, among many other possibilities (PierNext, 2018). The possible positive impact of Blockchain in Port Community System is visible in the Blockchain Port Community System. The port of Veracruz, Mexico, has contracted blockchain logistics company dexFreight to develop a proof-of-concept project for a blockchain port community system (Business Blokchain HQ, 2018). The goal is to develop a blockchain-driven port community system (PCS) for improving the efficiency of freight and logistics at the port as well as optimizing and streamlining the carrier onboarding processes. Another example is blockchain-powered Cargo Community System. The data in Cargo Community System is gathered from various sources, including shippers, customs authorities, freight handlers, port agents and road haulage companies (SAFETY4SEA, 2019). The goal is to streamline and speed up cargo data exchange between all private and public stakeholders (PortSEurope, 2019).

5 Discussion and future perspective of selected disruptive innovations in electronic transportation management systems

As mentioned above, a transportation management system is a platform that streamlines the shipping process, including planning and decision making (AQT Solutions, 2019). Blockchain, a new decentralized database technology, could help to increase collaboration, the sharing of trusted information and efficiency, reduce costs and risk, and forge new business models in the transport sphere over the coming years, thus enabling simplified planning and improved decision making (Mukherjee, Carter, & Koh, 2018). For example, Maersk and IBM joined together in order to develop a Blockchain solution aimed at digitalizing global trade, and they called it "Tradelens". Furthermore, inspired by this initiative, other established industry actors have also begun to form their own partnerships or to join industry wide consortiums hoping to reach the promised benefits of Blockchain technology. According to IBM, the joint Blockchain initiative had the potential to "vastly reduce the cost and complexity of trading" ("Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain," 2017).

Various experts consider that successful Blockchain implementation is possible only if all stakeholders are involved in the process, such terminal operators, manufacturers, banks, insurers, brokers and port authorities. As long as Blockchain technology exists only in a limited area within the smaller pilot projects, benefits of Blockchain technology (e.g. reducing time of document processing) will not be fully exploited (Marija Jović, Filipović, et al., 2019).

Furthermore, one of the transportation management system's shortcomings is the following: the monitoring information is confined to the positioning and geographical information of the goods or vehicles without the physical status sensing during the transport procedure (Xu et al., 2017). However, in the last few years several projects that involve Big Data have been initiated, for example in Oslo Fjord, where the data was collected from different sensors of the ships and transmitted to the captain and the staff in real-time after proper optimization (Nita & Mihailescu, 2017). The results were promising: the routes have been optimized as a consequence of recalculation enabled by real-time tracking data provided by the ships' sensors, the temperature of refrigerated containers was provided, and the equipment was monitored, all in real time (Nita & Mihailescu, 2017).

According to (Zghurovsky & Zaychenko, 2019), "Data extracted from IoT devices provides a mapping of device interconnectivity. IoT is also increasingly adopted as a means of gathering sensory data, and this sensory data has also been used in transportation contexts".

The evolution of IoT and the use of Big Data creates the prospect of logistics becoming a data-centric industry, where information takes precedence in logistics services' value propositions over the actual ability to move cargo (Theo Notteboom, 2017).

6 Conclusion

Transportation consists of different categories and activities (such as: policymaking, planning, designing, execution) and involves interconnected stakeholders who have to exchange various documents (such as the Bill of Lading). Maritime transport is the main mode of transport in a global trade. Due to the existence of numerous

stakeholders and large volumes of data, it is necessary to simplify and accelerate data exchange.

Transportation management system is an electronic platform which streamlines the shipping processes. It allows monitoring of physical or administrative operations regarding transportation, planning and decision-making. Several shortcomings of e-TMS exist, such as the lack of a uniform data transferring capability that can prevent simplified data exchange among stakeholders. Furthermore, RFID technology in TMS does not provide the information about the cargo through the entire transport process.

Companies in the maritime transport sector are facing notable challenges resulting from the emergence of disruptive technologies, for example, Blockchain technology immaturity, lack of regulation, and security and privacy issues. Nevertheless, disruptive innovations definitely possess the potential to improve transport business. Blockchain, Internet of Things and Big Data technologies are singled out due to their promising characteristics and the potential for simplifying procedures, enhancing cargo monitoring and better decision making.

Through the literature review and provided cases, authors have pointed out the importance of selected disruptive innovations in electronic transportation management systems. Blockchain-driven port community system aims to improve the efficiency of freight and logistics at the port and to optimize and streamline the carrier onboarding processes. Internet of Things technology enables improved transparency, and better prediction of estimated time of arrival. The conjunction of Big Data and IoT can be exploited to enable real-time tracking of ships and equipment. On the other hand, if the perimeter of disruptive technologies' implementation is limited to the smaller pilot projects, the benefits of the technologies will not be fully reaped.

This research is based on the literature review and considers three selected disruptive innovations (which is also the main limitation of the research), and as such offers the initial overview of the importance of disruptive innovations in e-TMS. Future research will include other disruptive innovations in order to obtain a broader insight of disruptive technology impacts on e-TMS.

Acknowledgements

This work was supported by Electronic Transportation Management System e-TMS project (New products and services as a result of research, development and innovation - IRI, Operational Programme Competitiveness and Cohesion, 2018 – 2020) and by University of Rijeka under the Faculty of Maritime Studies projects.

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(My) Data for (my) Health – Privacy Calculi of Terminally-ill Patients with Rare Diseases

Katharina Dassel[1] & Stefan Klein[1]

[1] University of Münster, Department of Information Systems, Münster, Germany,
e-mail: katharina.dassel@wi.uni-muenster.de, stefan.klein@uni-muenster.de

Abstract Digital healthcare information systems promise to improve care efficiency, to reduce complexity for patients, and to increase access to information and advance research efforts. A prominent example are multi-sided-platforms (MSP), which are essentially an information business, linking key healthcare stakeholders for individualized as well as aggregated information services. However, platform-based health innovation relies on the extensive collection, storage, and use of sensitive health information, raising issues of information privacy. This study uses the privacy calculus perspective to shed light on patients' trade-off considerations. We use the case of a MSP, which connects patients, care providers and researchers, in order to model a multi-level calculus for health information of terminally ill patients. These insights inform stepwise consent options, which highlight the trade-offs between information value and patient privacy. By reflecting on the implications for patient empowerment this conceptual paper develops a research agenda on how to study and design responsible health information systems.

Keywords: healthcare multi-sided platform, privacy calculus, patient empowerment, terminal illness, rare diseases.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.2
ISBN 978-961-286-362-3

1 Introduction

The delivery of healthcare and disease management are information intensive fields, in which the effective exchange of sensitive information is a crucial success factor. Digital technologies have started to transform healthcare worldwide based on promises of decreased costs and improved quality. Digital multi-sided platforms (MSP) act as intermediaries between different stakeholders such as patients, providers and purveyors (Davidson et al., 2018; Hagiu and Wright, 2015). Especially in light of severe neurological diseases like amyotrophic lateral sclerosis (ALS), healthcare providers struggle to keep up with the pace of the progressing symptoms and patients' increasing need for care, therapeutic interventions, assistive technologies, and medication (Funke et al., 2015). Here, MSP create new possibilities to promote a patient-centric model of care delivery and at the same time cut costs (Kuziemsky and Vimarlund, 2018). Several studies suggest that the use of information systems can enhance patient empowerment (Risling et al., 2017, Angst and Agarwal 2004, Deng et al., 2013).

However, there is a promise-delivery gap concerning technology and data driven improvement of healthcare. In order to close the gap, challenges and wider implications for all stakeholders need to be considered (Davidson et al., 2018). Platform-based healthcare innovation claims are premised on the centralization, access and efficient use of large amounts of sensitive information. Thus, information privacy is becoming a critical topic involving perplexing trade-offs for patients: They have to weigh promises of sharing information against the potential risks and concerns related to losing control over their information (Laufer and Wolfe, 1977; Culnan and Armstrong, 1999). The sharing of medical information is not limited to impacting individuals only but yields promises to advance public health research efforts of profound societal relevance. In the context of ALS, data driven care studies appear to be particularly promising as the disease is rare (about 1% of the population are affected) and without any known cure. In addition to progressing the body of medical knowledge, direct impact of research efforts for the patient community can be expected. Ethical discourses evolve around data donations and the question whether medical data should be considered a common good (Hummel et al., 2019).

While benefits of using large amounts of medical data to foster innovation, increase efficiencies or improve medical and care research become apparent, they must be balanced with protecting personal privacy. The issue of information exchange on a healthcare platform has rarely been examined from a patient perspective and with respect to patient sovereignty and empowerment (Shen et al., 2019). The purpose of this research is thus to use the privacy calculus perspective in order to illustrate the dilemmas of terminally ill patients in the context of a healthcare MSP. More specifically it will address the question: (*How) is it possible to balance information needs and patient privacy, while ensuring patients' empowerment?*

This research will examine multiple trade-offs that arise from patients' perspectives on numerous information purposes from a privacy calculus perspective. Our empirical setting is Ambulanzpartner Soziotech GmbH (APST), a MSP that orchestrates case management for severe neurological diseases. APST acts as an intermediary between patients and care providers, and thus as information aggregator, guardian and gatekeeper (Fürstenau et al. 2019). It also collects and uses information for research purposes. Based on a rich case description we first shed light on the particularities of the healthcare MSP and its information centric practices. Focusing on the patient's perspective, privacy calculus theory is used as lens on the value of personal health information. We have used an extreme case sampling strategy to select the case, expecting that it will yield more clearly articulated views on privacy trade-offs. We propose exemplary design options that have the potential to enhance patients' information sovereignty and meet information needs appropriately. Finally, we will discuss relevant implications and provide an outlook for empirical investigations.

Our contributions are twofold: First, we contribute to the information privacy literature by enhancing the understanding of terminally ill patients' privacy perceptions in a digital healthcare context. We explore possible contingency factors that extend the privacy calculus in this realm. Second, we inform the design of a stepwise consent option that paves the way for an informed calculus. We further discuss and reflect on implications of platform-based information exchange in healthcare for patient empowerment to enable responsible healthcare innovation.

2 Case Background

We use an extreme case to examine data-based healthcare management[1]. The operating logic of APST and the nature of information exchange via the healthcare MSP provide a backdrop for a deeper understanding of the trade-offs that patients face.

2.1 Platform-based Innovation for ALS Care

ALS is considered a "relentlessly progressive and fatal neurodegenerative disease characterized by progressive weakness of voluntary muscles of movement as well as those for swallowing, speech and respiration" (Soriani and Desnuelle 2017, p. 288). Due to the severity and swift progression of the symptoms, patients are not only overwhelmed by the dire prognosis of a non-curable disease, but face challenges of organizing and adjusting medical care and assistive technology as the disease progresses. Thus, ALS care has profound ethical issues during treatment and care (for a review, see Seitzer et al. 2016). One of the several shortcomings in the German ALS Care System is the significant delay of providing assistive technology due to long insurance approval processes (Funke et al., 2015). APST aims to address these gaps and provides an illustration of how a digital health platform can facilitate the coordination and inter-professional cooperation of multiple providers as a multi-sided transaction platform model. APST is operating under two different logics: providing care management on the one hand and functioning as research infrastructure on the other. By maintaining the electronic health record and connecting patients and doctors with care providers and assistive technology providers, the platform aims to transform the field to a new way of care orchestration. Opportunities are created that lead not only to complexity reduction for individual patients but also promise an increase in efficiency and effectiveness of care provision (Fürstenau et al., 2018). Patient feedback on care services and devices is solicited in order to improve the quality of care and faciltiate a learning cycle. At the same time, the platform is connecting the patient pool with research partners to conduct medical and care studies or improve platform efficiency. Thus, the disclosure of personal health information holds not only potential benefits for the

[1] Based on purposeful sampling and extreme case selection (Yin, 2009) we investigate a rare and terminal disease. The distinctive setting of a disease with no known cure functions as a magnifying glass to patient's perceptions and reveals specificities of risk and benefit perceptions that emerge and manifest themselves in a more pronounced way in this context.

orchestration of patients' care but also for the platform and the related partners (service providers and researchers).

2.2 Information as Main Resource

Innovative modes of interaction are possible because of patient's health and medical information: As a digital intermediary, which collects, stores and redistributes information, APST relies on the extensive use and economization of patient data. APST thus combines the data-economy logic of information accumulation with the goal of providing a patient-centric care model. This raises potential conflicts of interest as it takes practices critically discussed in the context of data capitalism (Zuboff, 2019) to the realm of care. For APST, patient information is one of the main resources. Drawing on Levitan (1982), we depicted the information lifecycle for APST in Figure 1.

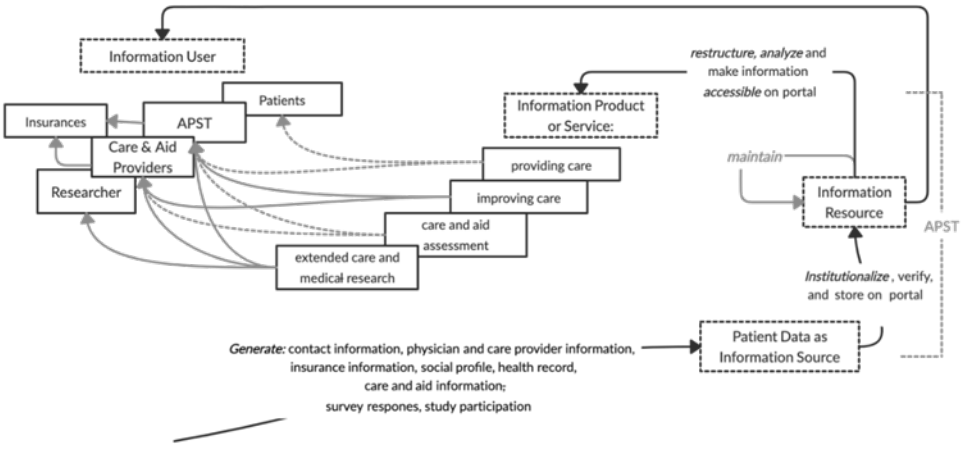

Figure 1: APST Information Resource Lifecycle
(adapted from Levitan, 1982, p. 48)

Information is acquired and generated by patients who provide personal information or a health record to the platform, give feedback or respond to surveys and take part in trials. By storing it centrally, APST is able to transform and prepare the information for further purposes. The different modes of interaction and the different stakeholders that are involved are illustrated by the flow of information via

information products to the various users. The information lifecycle sheds light on the dynamics that arise with information as the main resource from the perspective of APST and illustrates the diverse purposes and types of use for collected information. Patient information, which is provided by consenting patients, is essential for a successful operation of the platform. Empowering patients to make informed choices about providing information is crucial in order to ensure that APST is not only extracting value from the information but also – and primarily - creating value that will benefit patients. It is therefore crucial to understand how patients reach the decisions to consent and to share. We take the patients' perspective and model trade-offs initially within the parameters of the case before discussing options of generalizability.

3 Health Privacy Calculus of Terminally Ill Patients

3.1 Related Work

Information privacy has triggered a significant stream of interdisciplinary research (Smith et al., 2011). Due to the sensitive nature of relationships it has been a long-recognized issue in healthcare. Health information privacy research that addresses the patient's perspective has mainly considered concerns (Rindfleisch, 1997), risk perceptions, and information sensitivity which were found to influence the adoption of electronic health records (EHR) among others (Angst and Agarwal, 2009). The privacy calculus was introduced to social sciences by Laufer and Wolfe (1977). Following elaborations by Culnan and Armstrong (1999) it was refined and extended in order to explain how online users weigh privacy related risks against benefits, and became a prominent topic in IS research (Dinev and Hart, 2006). The examination of trade-offs has also been applied to health-related decisions (Dinev et al., 2016). Health information is perceived as having the highest risk profile compared to other personal data, when sharing decisions are considered (Milne et al., 2017). Next to information sensitivity, health information privacy concerns that address the use, collection, and access to information play a major role (Kenny and Connolly, 2016). To mitigate the effects of risk as a major inhibitor, control and trust are discussed. Perceived benefits and promises that are tied to the information sharing can compensate the perceived risks. Convenience, internet experience or personal factors (like emotions) were proposed to influence the calculus and attitudes of patients (Anderson and Agarwal, 2011; Dinev et al., 2015). We use the lens of the

privacy calculus to develop a better understanding of privacy trade-offs in interorganizational relationships from the perspective of the data subject.

3.2 Patient's Privacy Trade-Off

Following we take the perspective of the ALS patient to examine and sketch out the relevant considerations in consent situations regarding APST. Perceived risks and benefits depend on the purpose of information usage. Thus, we distinguish between the main purposes or information products, as elaborated in the information lifecycle, to model the trade-offs that arise. In Table 1, type (1-10) and purpose of information (A-E), are tied to promises that a consent would yield, followed by potential risks. We model the perceptions based on publicly available information from APST, most is inferred from the data protection declaration (APST, 2020).

APST makes potential benefits (promises) related to different information purposes tangible for the patient. Also, secondary benefits like hopes for improvement for future patients, that do not directly relate to the individual patient, are likely to play a role. The table suggests that benefits can be tied to type of information and purpose, while this is not obvious for risks. Privacy valuations are sensitive to contextual and non-normative factors (Acquisti et al., 2013). The special context of ALS calls for distinct considerations: As ALS is a rare disease, additional information for research (D, E) is even more valuable. This however also gives rise to additional risks: with a small sample, the risk of deanonymization is higher. Patients with special and immediate care needs tend to be more interested in necessary care transactions than in concerns about their privacy (Lafky and Horan, 2011). This is presumably the case for ALS patients as the disease manifests quickly. The risk of leaking information to employers or others becomes irrelevant as soon as the disease becomes manifest and insurance providers are inevitably informed once they need to approve aid. Patients emotional responses might also play a role as it was indicated that altruistic perceptions can outweigh risks (Spencer et al., 2016).

Table 1: Privacy calculi of APST patients

Patient Information	Purpose of information for APST	Patients' Potential Benefits		Patients' Privacy Concerns and Risks
		Tangible	Secondary	
1 Contact information, 2 physician, care providers 3 insurance information, 4 social profile, 5 health record, 6 care and aid information,	A Care management	Free usage of platform, care provision and case management	Reduced complexity for relatives	a) Leakage, b) concern about inappropriate use, c) uncertainty about future use, d) uncertainty about information use and protection by platform partners e) possibilitiy of de- and re-contextualization f) deanonymization, (dependent on statistical parameters of the patient sample), g) risk perception of IT infrastructure (cloud services, hosting),
	B Improving care, process efficiency	Better and faster care, improved insurance management	Benefits of collective information sharing, funding for the platform	
anonymized 7 survey responses, 8 feedback about assistive device or care, 9 care studies 10 medical trials/ studies 11 patient specific information	C Feedback/ evidence-based care and aid assessment and improvement	Care providers can take feedback into account, overview over rating on website,	Improved care and aid technology over time and for future patients, platform funding	
	D Care research	Advanced body of knowledge that can improve individual condition	better care for future patients, public health improvement	
	E Medical research	individualized treatment (medicine, assistive devices)	medical progress, solidarity and altruistic behavior as motivator	

Another boundary condition to consider is trust: while APST aims to create a trustworthy environment, the complexity of the relationships orchestrated by the paltform can lead to misspecifications of trust (Möhlmann and Jarvenpaa, 2019). By drawing on relevant literature as well as the parameters of the case, we conjecture that terminally ill patients perceive higher benefits from sharing information.

4 Towards an Informed Consent Calculus

4.1 The Consent Dilemma

Terminally ill patients depend on efficient and effective orchestration of healthcare. In order to receive care, information exchange with doctors and caregivers is inevitable. In situations of advanced care needs, however, the patient is typically under enormous emotional strain, left with no time nor meaningful decision rights. This stands in stark contrast to the assumptions of economic rationality underlying the privacy calculus, as patients will most likely not be able to actually fully assess risks and benefits. Promises or benefits are most often tangible, while risks are delayed and hard to grasp (Acquisti et al., 2015). APST has addressed both, legal requirements and the aim to provide transparency to patients, with an extensive privacy policy, which needs to be signed by all stakeholder (APST, 2020). However, research has shown that privacy policies are often neither understood nor read, instead they may increase information asymmetries. Therefore, users' need to consent to conditions they are not able to comprehend creates a consent dilemma (Solove, 2012). It thus seems crucial to effectively empower patients in the context of a healthcare MSP, so that they understand the implications of their options as prerequisite for an informed and meaningful privacy calculus.

4.2 A Stepwise Consent Model

By proposing an exemplary stepwise, and dynamic option for consent we aim to illustrate how patients can be empowered to apply an informed mental calculus in the context of APST. Dynamic consent has been discussed in medical research for means of ethically gathering data for clinical trials (Spencer et al., 2016). Through legal advancements, dynamic consent has found its way into cookie consent management. We apply this approach to examine how a consent situation can be created that integrates the calculus and enables the patient to make an educated

decision. In Table 2, we depict a possibility to manage information provision consent for APST in a similar fashion. We translate the findings from Table 1 and Figure 1 in order to establish a consent option, that allows to differentiate between type of information and different purposes. We have developed one of the hypothetical consent options to share aid and medical data for information types 6, 9 and 10.

Table 2: Illustration of Consent Options

Your Information	Your consent options					
	collection and use of trans-actional infor-mation	**sharing** of trans-actional infor-mation	**analysis of personal** infor-mation	**analysis of anony-mized** infor-mation	sharing of anonymized information with **care research partners**	sharing of anonymized information with **medical research partners**
6 care & aid information	x	x		x	x	
9 care studies	x	x		x		
10 medical trials	x	x				

Show information:
Information about you, your care and aid prescriptions, usages, provider and physician information is neccessary to perform a transaction. For a transaction, we only share the minimum of relevant information needed. You can choose to provide this data in personalized or anonymized form for further analysis which helps to improve care efficiency, or provide it to relevant research efforts to advance care and medical research

We draw on psychological empowerment to inform this option further. Psychological empowerment is based on the concepts of autonomy, self-efficacy, meaning and impact (Spreitzer, 1995), which are reflected in patient empowerment (Bravo et al., 2015, McAllister et al., 2012). The options to decide for which purpose and in which form patient information is used, would enable patients to make informed and differentiated choices about sharing information. A consent option like the one depicted would illustrate the data driven logic of the platform. With a comprehensive overview, patients are presumably more capable to assess the impact of information sharing. We could better inform patients' privacy calculus by providing the information necessary to make a good judgement of personal risks

and benefits. We try to address uncertainty about future use by providing an overview over a range of possible purposes. In this way, we make the information lifecycle transparent for the patient. Being provided with further details on the consent decision, patients would not only have more control and autonomy in their privacy decision making but also understand the impact of their choice which enable them to attribute meaning to their consent. As privacy preferences are also not stable but evolving, it would be useful to apply this consent form dynamically. With the options to make convenient and economic choices we thus aim at patients' psychological empowerment.

5 Discussion, Limitations and Outlook

In the consent context of the case, patients act as active information contributors. By providing stepwise and dynamic consent, the patients' ability to make informed decisions is extended. She is now able to choose if, how, and to whom power over personal information is transferred. Acting in the patients' interest, APST thus takes on the role as an information trustee. By taking into account individual preferences, information provision can therefore be considered an exercise of sovereignty (Hummel et al., 2019). Still it needs to be critically assessed, if privacy in a data driven business model can truly be balanced in this way. It is conceivable, that reactance behavior is triggered and patients, as a matter of principle, have higher cautions for privacy and choose not to share information at all. Patients potentially react the same way as consumer who scrolls through software update notifications, leading to higher information asymmetries and a privacy apathy instead of information sovereignty (Hargittai and Marwick, 2016). In turn we argue that the problem of patient information overload can be mitgiated by structuring the decisions and presenting them in a way that faciltiates information consent, thus making it a design issue. A clear limitation is that we merely provide an exploration based on the theoretical as well as the case background and can not empirically validate perceptions and consent options. The rich theoretical background and the specific case insights, however, pave the way for this empirical examination of patients' privacy calculus towards a multi-level use of information on a healthcare platform. Further examination is needed to investigate the differences in perceptions and valuations, to see, how they relate to the different usages of information on the platform. In this way, the options that we modeled in chapter four need to be refined and empirically validated. This paper provides a hypothetical form of enhanced

consent and further research needs to show how this leads to an increase in perceived empowerment. A first step would be to explore patients' privacy perceptions under the calculus framework. Modelling these valuations into the consent options, psychological trade-offs that are considered between the different options could be assessed. To do so, we propose a conjoint analysis. Thus, we will also be able to examine the relative importance of different bundles of options to truly understand what terminally ill patients perceive as empowering.

6 Conclusion

We have shed light on the dynamics of a healthcare MSP, which strives on various categories of patient information (see table 1) as main resource. Adapting the information lifecycle we show how the platform is drawing on a logic of accumulation, feedback based-learning and cautious monetization typical for business models in the data economy, yet with the explicit goal to improve patient care, care research, and medical research and thus create value for patients.

Information intensive practices incur considerable privacy concerns. We provide insights in the distinct perspective of terminally ill patients' privacy perceptions and decision making. This understanding opens up possibilities to enhance a patient-centered design in the light of a severe neurological disease. We propose a stepwise consent form to inform meaningful privacy options and to empower patients that interact with the healthcare platform. This provides an avenue for further empirical examination of patient empowerment that balances platform innovation, care, and medical research with information privacy. In this way, our research further contributes to the advancements of responsible and sustainable healthcare innovation and research practices.

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Real-time Inpatients Risk Profiling in Acute Care: A Comparative Study of Falls and Pressure Injuries Vulnerabilities

Chinedu I. Ossai[1], Louise O'Connor[2] &
Nilmini Wickramasinghe[2,3]

[1] Swinburne University, Faculty of Health, Arts and Design, Hawthorn, Australia, e-mail: cossai@swin.edu.au
[2] Epworth Healthcare, Hawthorn, Australia, e-mail: Louise.O'Connor@epworth.org.au, nilmini.work@gmail.com
[3] Swinburne University, Faculty of Health, Arts and Design, Hawthorn, Australia, e-mail: nilmini.work@gmail.com

Abstract To effectively manage patients of different vulnerabilities to falls and pressure injury entails understanding the risk drivers and predicting risk profiles in real-time, thus, we determined the core drivers of patients' proneness to these risks while developing a machine learning strategy for their real-time prediction in acute care hospital. By implementing a multivariate logistic analysis, the risk drivers and injury risk probabilities were obtained while establishing a comparative machine learning technique for patients' risk-profiling. We observed Multi sclerosis & motor neuron disease (MSN) and Fall during current admission (FDA) as pronounced risk drivers, and Extra Tree Classifier (ETC) and Random Forest (RF) as the best algorithms with prediction accuracy of 90.6% - 99.8%. With a cost saving of 2.3% - 38.89%, our framework will provide an efficient technique for cost-effective management of inpatients susceptible to falls and pressure injury risks on admission.

Keywords: acute care, cost-effective, fall risk, inpatient, pressure injury risk, risk profiling.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.3
ISBN 978-961-286-362-3

1 Introduction

Understanding patients' vulnerabilities in acute care hospitalization is vital for efficient management of some underlying risks associated with admission. Thus, early identification of those at high risk of falls or pressure injuries will allow the hospital to mitigate the risks. Falls and pressure injuries are known to be among the most pronounced risks patients face in hospitals with 32%-40% exposed to falls risk (Florence et al. 2018) whereas 2% - 23% are exposed to pressure injury (Gallagher et al. 2008, Moore et al. 2019) annually. Although researchers have released important findings of the factors influencing falls and pressure injury (Gallagher et al. 2008, Moore et al. 2019, Geusens et al. 2003), their focus have revolved around the aged (>65 years) without considering the other age groups, who can be equally susceptible due to health conditions.

Since the knowledge of patients' risk on admission is somewhat limited due to the greater emphasis on the elderly, it is imperative that this study will critically look at the contributing factors to these admission risks for all age groups by exploring the various clinical and psychosocial factors. This information can help to improve care and reduce cost, thus, reducing the slow pace of evaluating falls and pressure injury risks of inpatients. Since biases can be reduced via an autonomous strategy that relies on the routine patients' record for decision support, we can expect improved risk estimation accuracy. Hence, this study will establish the factors responsible for different risk levels of falls, pressure injury, and falls and pressure injury for inpatients on admission using multivariate logistics regression analysis while developing a machine learning model for predicting the risk levels. The cost-saving from using the model will also be developed for various length of stay (LOS) for high-risk patients who are most predisposed to injuries on admission.

2 Background

Pressure and fall injuries are among the danger patients face on admission in acute care hospitals. It has been established that over 70% of hospitalized patients get involved in fall accidents (Coussement et al. 2008) with 2%-15% in acute hospitals (ACSQHC 2018a). Most of these injuries resulted in fracture and intracranial injuries, which affect 4 in 10000 patients in Australia annually (Black et al. 2011). For elderly patients, 30%-50% of falls cause them minor injuries that include bruises,

abrasions, and lacerations. However, 10%-16% of these falls cause intracranial injuries and fractures, which significantly result in morbidity and mortality (Ahmad et al. 2012). Numerous studies have linked falls and fall injuries amongst patients to postural instability, blood pressure, dementia, menopause, previous history of falls, orientationally problems, dizziness, mobility problems, and medications (Margolis et al. 2014, O'Neil et al. 2018, Nguyen et al. 2015). Although the effects of numerous disease conditions on the fall rate vary with the severity of the ailments, dementia patients have more than 3 times the risk of falls than other patients. There is an increased risk of falls for patients that use antiepileptic, sedative, hypnotics, antidepressants, and benzodiazepines-based medications (Woolcott et al. 2009, Hartikainen et al. 2007, Neutel et al. 2002). Similarly, the risk of falling increases for patients taking more than 10 medications together than those on high-risk fall inducing medication such as benzodiazepines (Tayyib et al. 2015).

Pressure injuries such as ulcers occur due to infrequent positioning and age of patients (Tayyib et al. 2015) but enhanced patients management in preoperative settings help to prevent them. Thus, ensuring that patients are not exposed to lengthy pressure during surgery and preventing exposure to frictions during transfers could potentially minimize the risks of pressure injuries (Spruce 2017, Posthauer et al. 2015). Poor hydration and nutrition also play significant roles in the development and exacerbation of pressure injuries (Alderden et al. 2018) especially for the critically ill who may be malnourished during the sickness episode (O'Neil et al. 2018, Nguyen et al. 2015). Not much has been done in predicting falls and pressure injury on admission using machine learning, however, Electronic Medical Records (EMRs) and algorithms such as random forest (RF), Bayesian network, artificial neural network (ANN), and decision trees have been employed by researchers (Alderden et al. 2018, Veredas et al. 2015, Kaewprag et al. 2017, Moon and Lee 2017). These researchers obtained an accuracy measured as the area under the curve (AUC) in the range of 78.7%-89.51%. Other authors have relied on different algorithms for fall detection and classification of videos and signals from wearable devices (Aziz et al. 2017, Ni et al. 2012). Some of the studies have been used to detect fallen residents in aged care facilities or homes whereas others have applied machine learning comparatively with the traditional methods of assessment based solely on scores (Silva et al. 2017). Despite the importance of these studies, there is still a limited focus on real-time profiling of patients' risk levels on admission and the risk level of

individuals with proneness to both fall and pressure injury not targeted yet. Thus, the need for this study that highlights the risk factors of both fall and pressure injury separately and collectively, determine the algorithm that will enhance the real-time estimation of risk vulnerabilities and comparatively establish the cost variabilities.

3 Method

This study established the risk profile of patients admitted to a not-for-profit acute care hospital by predicting the fall and pressure injury risks of 1014 patients admitted between December 2016 to July 2018. This sampled population consists of patients aged 1.17 years to 101.25 years with 48 clinical, demographic, and psychosocial characteristics that are closely related to the risks under consideration. The risk levels of the patients that were classified as low, moderate, or high were also obtained from the hospital records. The patients at the risk of fall and pressure injury were extracted from the acquired record by letting high-risk level to supersede either the low or moderate risks for patients susceptible to both risk profiles. Similarly, moderate risk superseded low risk when a patient is exposed to low and moderate risk levels.

Due to the need to establish the factors driving falls, pressure, and the combined falls and pressure injuries of the patients, multivariate logistic analysis of the patients at low, moderate, and high-risk categories were determined and the odds ratios (ORs) established. Different machine learning algorithms that include ANN, gradient boosting model (GBM), RF, Linear discriminant analysis (LDA), K Nearest Neighbour (KNN), Adaboost (ADB), Ridge regression classifier (RCV) and extra tree classifier(ETC) were tested to establish the best algorithm for real-time prediction of the risk profiles. The cost savings from using the real-time estimation was also determined for different LOS.

3.1 Pre-processing of data

The data were cleaned to remove inconsistencies in the entry and parameters with more than 10% of missing values dropped whereas others with less than 10% were filled. Hence, patients at high risk of fall or pressure injury and have a stroke, heart problems, multiple sclerosis, and motor neuron diseases, asthma, breathing problems, fall during current admission, and are passing through chemotherapy and radiation treatment were treated as high-risk patients if they have missing values. The risk classes were later upsized with Synthetic Minority Oversampling Technique

(SMOTE) to ensure a class balanced data while categorical parameters such as the clinical services and gender were characterized dichotomous as "1" for affirmative or "0" if not.

3.2 Factors influencing risk profiles at different levels

The factors influencing the risk categories of fall and pressure injury susceptibility were established at 0.05 significant level following a multivariate logistics model.

3.3 Real-time estimation of patients' risk profiles

It is important to establish the machine learning algorithms that will result in a better prediction of the risk classes by testing numerous algorithms. They include Ridge Regression (RCV, Linear Discriminant Analysis (LDA), Gradient boosting machine (GBM), Random Forest (RF), Artificial neural network (ANN), K Nearest Neighbour (KNN), Adaboost (ADB), Support Vector Machine (SVM) and Extra Tree classifier (ETC). The performance of the real-time risk profiling model, sensitivity (recall), specificity(precision) and accuracy were determined using the True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN).

3.4 Cost optimization with real-time risk profiling

To estimate the cost-savings associated with the patients LOS on admission when real-time risk profiling is carried out, it was assumed that $\$\eta$ is spent per day of hospitalization. If φ patients were treated for ψ days, the total expenditure (E_{tot}) can be represented by Eqn. (1).

$$E_{tot} = \eta\varphi\psi \quad (1)$$

If Υ number of falls or pressure injuries results in λ increase in the LOS of the patients following the findings from previous researchers (Worsley et al. 2016, Morello et al. 2015, ACSQHC 2018b), the cost of managing the patients in consideration of those that have fall or pressure injury (E_{inj}) will increase following the additional days spent by the injured patients per Eqn. (2).

$$E_{inj} = (1 - \Upsilon)E_{tot} + \Upsilon\eta\varphi(\lambda + \psi) \quad (2)$$

Since real-time risk profiling results in the prediction of the inherent risk of falls and pressure injuries to an accuracy of β, the extra cost incurred by treating the injured patients will be reduced by (1-β) times of the cost of managing injured patients $\{\Upsilon\eta(\lambda+\psi)\}$ because of the expected fewer casualties. Thus, the cost of managing the patients when real-time risk profiling is carried out (E_{rsk}) can be represented by Eqn. (3).

$$E_{rsk} = (1-\Upsilon)E_{tot} + E_{tot}(1-\beta)(\lambda+\psi) \quad (3)$$

The cost-saving expected from using real-time risk profiling (E_{sav}) is obtained as the difference between Eqn. (2) and Eqn. (3) and the percentage of savings can be computed with Eqn. (4).

$$E_{sav} = \left(1 - \frac{(1-\Upsilon)\psi + \Upsilon(1-\beta)(\lambda+\psi)}{(1-\Upsilon)\psi + \Upsilon(\lambda+\psi)}\right) * 100\% \quad (4)$$

3.5 Injury probability on admission

The injury probability of the high-risk patients is determined by computing the mean risk index following the expressions shown in Eqn. (5) – Eqn. (6).

By using a logistic regression model with binary dependent variable y_i representing patients of high-risk susceptibility P ($y_i = 1$), the probability of injury proneness can be written as Eqn. (5).

$$p(y_i = 1) = \frac{e^{(\beta_0 + \sum_{i=1}^{m} \beta_i x_i + \varepsilon)}}{1 + e^{(\beta_0 + \sum_{i=1}^{m} \beta_i x_i + \varepsilon)}} \quad (5)$$

Here, β_0, β_i, m, and ε is the intercept, coefficient of a given patient characteristics (clinical and psychosocial) x, number of explanatory variables in consideration and random error. The mean values of the patient characteristics x are used alongside the coefficient estimated with Eqn. (5) to compute the mean risk index (MRI) in Eqn. (6).

$$MRI = \frac{\sum p(y_i = 1)}{\sum AGE} \quad (6)$$

4 Results

The summary of the clinical and psychosocial characteristics of the patients shown in Table 1 has 59.3% females and 40.7% males, and the proportion of the patients admissioned for various disease conditions.

Table 1: Summary of the clinical and psychosocial conditions used for modelling fall risk on admission and the proportion of patients associated with the studied conditions.

Demographic information		
Parameter	Mean ± SD	
Age(years)	48.59±22.08	
Weight, WGT(Kg)	79.81±25.56	
Height, HGT(cm)	168.46±12.98	
Body Mass Index (BMI)	27.96±8.03	
Length of stay, LOS (days)	6.53±11.89	
Psychosocial and clinical conditions		
Condition	**Acronym**	**Total**
Arthritis	ARS	16%
Asthma	ASM	19%
Bowel bleeding, constipation & diarrhoea	BBC	18%
Blood clotting problems	BCP	6%
Bladder problems & incontinence	BPI	10%
Breathing problems	BRP	18%
Cough & cold in the last 2 weeks	CCL	13%
Cancer	CNR	22%
Chemotherapy & radiation treatment	CRT	15%
Current wounds & skin breaks	CWB	12%
Dentures	DEN	14%
Dementia	DMA	1%
Diabetes	DTS	8%
Epilepsy & seizures	EPS	3%
Fall during the current admission	FDA	3%
Fallen in the last 6 months	FIL	13%
High and low blood pressure	HBP	28%
Hospitalisation in the last 12 months	HIL	47%
History of multi residual bacteria	HMB	2%
Home oxygen	HOX	4%
Heart problems	HTP	13%
Infectious diseases	IFD	1%

Indigestion & reflux	IRF	21%
Impaired vision & hearing	IVH	26%
Kidney disease	KDS	5%
Lives alone	LAL	10%
Limited jaw movement	LJM	2%
Migraines & motion sickness	MMS	17%
Multi sclerosis & motor neuron	MSN	2%
Neck & back problems	NBP	25%
Pregnant & breastfeeding	PBF	1%
Physical disability & mobility problems	PMP	16%
Prostate problems	PRP	6%
Psychiatric problems	PSP	20%
Short term memory loss	SML	5%
Speech & swallowing difficulties	SSP	4%
Stroke	STK	5%
Vaccination for chickenpox	VCP	25%

4.1 Combined falls and pressure injuries risks

The conditions that influenced the risk of injuries for patients that are susceptible to both falls and pressure injuries risks are summarized in Table 2. The influence of MSN, which carries the highest risk for patients at high risk is quite pronounced with 59% - 811% more likelihood of causing injuries than the other influencing variables. FDA poses lesser risk than MSN but has between 194% - 473% more chances of triggering falls and pressure related injuries on admission than the HGT, AGE, VCP, and FIL.

Table 2: Summary of features influencing combined fall and pressure injury of high risks susceptible patients on acute hospital admission

Parameters	**P values**	**2.50%**	**97.50%**	**OR**
HGT	0.00002	0.97	0.99	0.98
AGE	0.00318	1.01	1.04	1.0251
FDA	0.00379	1.75	18.04	5.6117
MSN	0.01857	1.44	55.24	8.9266
VCP	0.02117	1.09	2.85	1.7616
FIL	0.03756	1.04	3.50	1.9059

The summary of the various algorithms used for the real-time estimation of falls and pressure injuries risk is shown in Table 3.

Table 3: Summary of training and testing results of the combined fall risk and pressure injury risks;fld:fold; ALG: algorithm; PRC: precision; RCL: recall; ACC: accuracy of test data, bold indicates the best.

ALG	fld1	fld2	fld3	fld4	fld5	mean	Std.	PRC	RCL	ACC
RCV	0.66	0.58	0.63	0.60	0.59	0.61	0.03	0.64	0.62	0.62
LDA	0.68	0.60	0.64	0.62	0.63	0.64	0.03	0.65	0.63	0.63
GBM	0.89	0.88	0.89	0.85	0.89	0.88	0.02	0.90	0.90	0.90
RF	0.88	0.86	0.88	0.85	0.88	0.87	0.01	0.91	0.90	0.90
ANN	0.85	0.89	0.90	0.79	0.86	0.86	0.04	0.89	0.89	0.89
KNN	0.75	0.75	0.79	0.73	0.76	0.76	0.02	0.83	0.80	0.79
ADB	0.75	0.77	0.73	0.72	0.71	0.74	0.02	0.74	0.74	0.73
SVM	0.64	0.60	0.62	0.62	0.65	0.63	0.02	0.65	0.62	0.62
ETC	0.87	0.90	0.90	0.86	0.89	**0.88**	0.02	0.91	0.91	**0.91**

The mean values of the 5-fold cross-validation of the training dataset indicate that ETC (in bold) as the algorithm that produced the best result with a mean accuracy of 88.4% of the cross-validation and 90.9% accuracy of the test data.

4.2 Falls risks

According to Table 4, the high risk of falls on admission is mostly influenced by MSN, which predisposes patients to falls injuries 538% more than the FDA, which is the second most influencing factor.

Table 4: Summary of the features influencing fall risks on the admission of high risks susceptible patients

Parameters	P values	2.50%	97.50%	OR
AGE	0.0008	1.01	1.05	1.0308
HGT	0.0017	0.97	0.99	0.9842
MSN	0.0026	2.89	153.38	21.0706
PMP	0.0328	1.06	4.00	2.061
DEN	0.0372	1.04	3.55	1.9211
FDA	0.0457	1.02	10.72	3.3119

The real-time estimation of falls risks can be predicted with RF per Table 5.

Table 5: Summary of training and testing performance of falls risks, fld:fold; ALG: algorithm; PRC: precision; RCL: recall; ACC: accuracy of test data, bold indicates the best

ALG	fld1	fld2	fld3	fld4	fld5	mean	Std.	PRC	RCL	ACC
RCV	0.68	0.67	0.72	0.65	0.67	0.68	0.02	0.67	0.67	0.67
LDA	0.69	0.68	0.71	0.64	0.69	0.68	0.02	0.67	0.66	0.66
GBM	0.91	0.88	0.93	0.89	0.91	0.90	0.02	0.90	0.90	0.90
RF	0.91	0.90	0.92	0.889	0.89	0.90	0.01	0.91	0.91	**0.91**
ANN	0.89	0.90	0.90	0.86	0.89	0.89	0.02	0.90	0.90	0.90
KNN	0.80	0.81	0.81	0.75	0.79	0.79	0.02	0.82	0.80	0.79
ADB	0.78	0.73	0.79	0.75	0.77	0.75	0.03	0.78	0.78	0.78
SVM	0.65	0.68	0.72	0.65	0.67	0.67	0.03	0.67	0.66	0.66
ETC	0.94	0.89	0.91	0.91	0.89	**0.91**	0.02	0.90	0.90	0.90

4.3 Pressure injury risks

According to Table 6, pressure injury risks are caused by some of the parameters that influence the other risks discussed in the previous except for some new parameters that include CWB, LJM, and BMI.

Table 6: Summary of the features influencing pressure injury risks on the admission of high risks susceptible patients

Parameters	**P values**	**2.50%**	**97.50%**	**OR**
HGT	0.0002	0.88	0.96	0.92
FDA	0.003	5.07	2732.30	118.00
MSN	0.03	1.59	9228.94	121.21
CWB	0.0381	1.10	32.98	6.03
BMI	0.04	0.78	0.99	0.88
LJM	0.042	0.00	0.82	0.00

Table 7 also indicates that ETC predicted the test data to an accuracy of 99.8% compared to RF and GBM that estimated them at 99.4% and 98.6% respectively while other algorithms have lower estimates.

Table 7: Summary of training and testing performance of pressure injury risk,fld: fold; ALG: algorithm; PRC: precision; RCL: recall; ACC: accuracy of test data

ALG	fld1	fld2	fld3	fld4	fld5	mean	Std.	PRC	RCL	ACC
RCV	0.89	0.86	0.90	0.90	0.88	0.89	0.02	0.88	0.88	0.878
LDA	0.88	0.83	0.87	0.90	0.87	0.87	0.02	0.87	0.87	0.864
GBM	0.99	0.99	0.98	0.99	0.97	0.98	0.01	0.99	0.99	0.986
RF	0.99	0.98	0.98	0.99	0.97	0.98	0.01	0.99	0.99	0.994
ANN	0.97	0.97	0.97	0.97	0.99	0.97	0.01	0.98	0.98	0.979
KNN	0.90	0.86	0.88	0.86	0.87	0.88	0.02	0.91	0.89	0.884
ADB	0.91	0.92	0.90	0.92	0.90	0.91	0.01	0.89	0.89	0.890
SVM	0.83	0.85	0.86	0.86	0.85	0.85	0.01	0.86	0.86	0.856
ETC	0.988	0.985	0.985	0.99	0.985	0.989	0.00	0.998	0.998	**0.998**

4.4 Injury probability on admission for high-risk patients

The MRI of the patients considered in this study is 3.69E-03 yr^{-1}, 4.04E-03 yr^{-1}, and 9.59E-11 yr^{-1} respectively for those with combined falls and pressure injury risk, fall injury risk, and pressure injury risk. The risk for those prone to the combined falls and pressure injury risk is lower than those that are only prone to falls injuries. But the MRI of pressure injury-prone patients is relatively very small, which may be an indication of the limited occurrence of such injuries due to the proper management strategy. The injury risks increase with the age of the patients (Coussement et al. 2008), thus, making an 80 years old patient 23% more prone to falls injury than a 65-year-old. The elderly can be prone to atrophy of joint muscles, which could cause instability because of limited activities, and sometimes vitamin D deficiency may help to enhance poor gait functionality, muscle weakness, and osteoporosis (Vassallo et al. 2009). These conditions can be responsible for the increased frailty of the elderly and susceptibility to higher falls injury probability per Figure 1.

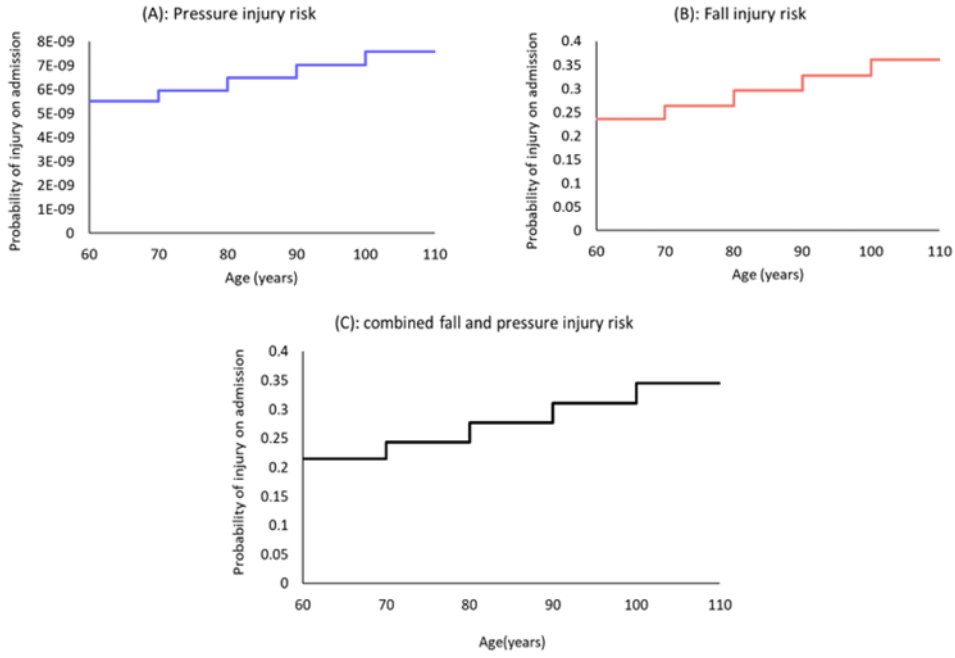

Figure 1: Probability of injury on admission for the patient that are 60 years and over – (A) pressure injury risk, (B) falls injury risk, (C) combined falls and pressure injury risk

4.5 Cost savings with real-time risk profiling

The real-time risk profiling using different algorithms showed that ETC and RF are the most efficient algorithms for predicting accurately the risk class of patients. This gives room for better patients' management that will forestall falls or pressure injuries on admission since the status of most patients can be known early enough. We have assumed that 2% and 3% of falls injuries and pressure injuries respectively are experienced on admission following information from the hospital. Since falls injuries can increase LOS significantly between 5.9 days – 23.6 days (Worsley et al. 2016, ACSQHC 2018b) and those with pressure injuries can stay more 8 days - 18.8 days (Black et al. 2011, Morello et al. 2015), the cost savings with different LOS has been computed with 90% accuracy of the real-time risk profiling (Figure 2).

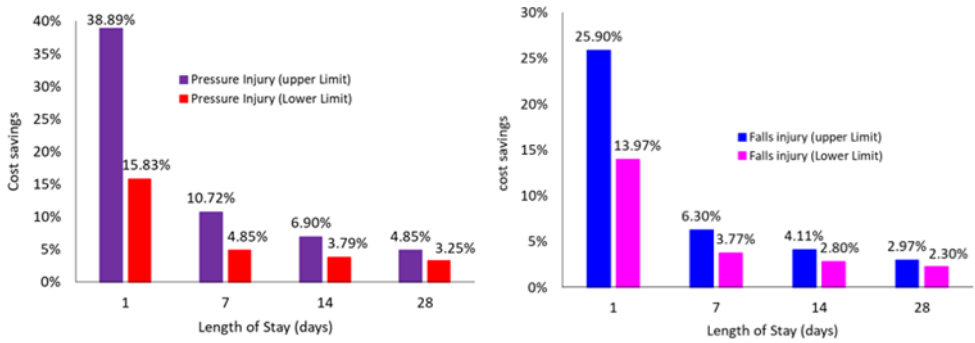

Figure 2: Expected cost savings using the risk-time risk profiling of patients in an acute hospital for different length of hospital admissions for – (A) pressure injury, (B) falls injury

5 Discussion

The core drivers of falls and pressure injuries have been identified to include HGT, FIL, VCP, CRT, DEN, LOS, AGE, SSP, FDA, DMA, MSN, PMP, BMI, ASM, LJM, HOX, SSP, BCP and CWB. Some of these conditions are among those identified previously by researchers however, they only influenced low and moderate risk patients and may not be of utmost concern like the ones influencing high-risk patients. Mobility problems and fall history, which were equally attributed to falls injuries in previous research were identified as among the conditions responsible for high-risk patients' susceptibility to fall injuries.

This study has linked patients diagnosed with high susceptibility to the falls and pressure injuries to MSN, FDA, FIL, VCP, AGE, LJM, BMI, CWB, AGE, and HGT but the strong influences of MSN and FDA make it imperative that patients who have these attributes will be given more attention. Although not so much is known about MSN, the pathological characteristics of death upper and lower motor neurons and the presence of numerous protein inclusions in the remaining motor neurons resulting in impaired transactive responses (Neumann et al. 2006,Wright et al. 2016) culminates in problems that can lead to poor gait and memory loss (Olivier et al. 2016). Thus, the strong influence of MSN on falls and pressure injures may be explained by the association between poor gait functionality and memory loss.

The probability of pressure injuries on admission is relatively low compared to fall injuries. This may be because of the healthcare strategy of the hospital which prioritise pressure injuries vulnerabilities. However, the probability of getting falls or pressure injuries increase with the age of the patients, the number and types of comorbidities (Rondinelli et al. 2018).

6 Conclusions

This study has affirmed the importance of real-time risk profiling in the efficient management of patients that are susceptible to falls and pressure injuries on admission by showing the cost-saving associated with the implementation of the technique. The core drivers of the risks were also established for patients with the various levels of predispositions to injuries while establishing the high-risk drivers that include MSN, FDA FIL, VCP, AGE, LJM, BMI, CWB, AGE, and HGT. The cost savings expected for real-time risk profiling ranges from 3.25% - 38.89% for pressure injury risks and 2.3% - 25.90% for fall risk injury when a 1 to 28 days LOS is considered. ETC and RF with enhanced accuracy of 10% - 11% were identified as the most efficient algorithms for predicting the patients' risk categories using the clinical and psychosocial conditions. Comparatively, patients prone to pressure injury risk have a very small likelihood of becoming injured on admission than those susceptible to falls risk and combined fall and pressure risks on admission. This could attest to the proper pressure injury management practices in the hospital and the need for improving fall mitigation strategies.

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DIGITAL STRATEGIC INITIATIVES: CONCEPTUALIZATION AND ILLUSTRATION

GABRIELE PICCOLI[1, 2] & JOAQUIN RODRIGUEZ[2]

[1] University of Pavia, Pavia, Italy, e-mail: gpiccoli@cct.lsu.edu
[2] Louisiana State University, Business Education Complex, Baton Rouge, United States of America, e-mail: gpiccoli@cct.lsu.edu, jrod122@lsu.edu

Abstract This essay responds to calls for discerning so-called IT "x" and digital "x" phenomena. Research in this area promises to make an important contribution since the emergence of digital "x" labels runs the risk of diluting the core of IS literature. Our paper advances a preliminary definition of key constructs: digital strategic initiatives and digital resources, differentiating the latter from traditional conceptualizations of IT or IS resources. It also delineates two different approaches to the execution of digital strategic initiatives: a) orchestration of digital resources and b) creation of novel digital resources. We demonstrate the first one with a case illustration of home grocery delivery and the second with the case of a dark kitchen provider in the restaurant industry.

Keywords: digital strategic initiative, digital resources, IT/IS resources, value creation, value appropriation.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.4
ISBN 978-961-286-362-3

1 Introduction

What is a digital strategic initiative? How does it differ from a generic strategic move or an IT-enabled Strategic Initiative? How can optimal digital strategic initiatives be *designed*, *implemented* and *sustained* over time by a firm intent on creating and appropriating economic value? These questions are central to the information systems discipline, and information systems research is best positioned to contribute to our collective understanding of digital innovation and digital transformation phenomena. It is however paramount that such contribution be based on sound ontological and definitional grounds, because the "consequences of ignoring ontological considerations of this kind are significant […] This problem is likely to be especially severe in the digital context" (Faulkner and Runde 2019, p. 1283).

To contribute to the discourse, this paper explores the *structure* and *design* of Digital Strategic Initiatives (DSI) - defined as *identifiable competitive moves* that depend on *digital resources* to *create and appropriate economic value*. Because they are competitive moves, DSIs are devised and implemented by organizations. As with any designed artifact, "to imagine a better design, the designer must know the relationships between structural elements" (Baldwin and Clark 2000, p. 34). It follows that when the structural elements change, as with the increasing availability of digital resources, the relationships between those structural elements change, and they create new design possibilities. Therefore, the premise of this paper is that in digital strategy the role of digital resources in crafting strategic initiatives, and the outcomes that are likely to occur from these initiatives, will be directly impacted by the nature of such digital resources. Specifically, the paper advances a precise definition of key constructs: digital strategic initiatives and digital resources, differentiating the latter from traditional conceptualizations of IT or IS resources.[1] The paper also delineates two different approaches to the execution of DSIs: a) orchestration of digital resources and b) creation of novel digital resources. We demonstrate the first one with a case illustration of home grocery delivery and the second with the case of a dark kitchens provider in the restaurant industry.

[1] For the remainder of the paper we will use the shorthand "IT" to refer to IT or IS resources, assets and capabilities.

2 Digital Strategic Initiatives

The strategic information systems literature defines IT-enabled strategic initiatives as "identifiable competitive moves that depend on the use of IT to be enacted, and are designed to lead to sustained improvements in a firm's competitive position" (Piccoli and Ives 2005, p. 748). This research tradition conceptualizes strategy "not as the making of a few discrete 'one time' decisions, but as the configuration of interrelated and interlocking activities. Thus, IT-dependent strategic initiatives do not simply consist of the building of a computer system or application that, allegedly, generates competitive advantage until it is successfully replicated; rather, they consist of the configuration of an activity system, dependent on IT at its core, that fosters the creation and appropriation of economic value" (Piccoli and Ives 2005, p. 748).

In keeping with the same conceptual level, DSIs are identifiable competitive moves that depend on the use of digital resources to create and appropriate economic value. Of interest to this discussion are only those strategic initiatives that could not be feasibly implemented by the firm without a core of specific digital resources. By definition, DSIs are predicated on digital resources use. The adoption of the term "digital" is intentional here, and it signals a substantive departure from the term "IT-dependent" (Piccoli and Ives 2005). While many authors and theorists agree that there is a difference between IT phenomena and digital phenomena (Hanseth and Lyytinen 2010; Kohli and Grover 2008), introducing new terminology begs the question of why the old label is not descriptive of the new phenomenon (Baiyere et al. 2017; Rodriguez and Piccoli 2018). This challenge is addressed in the next section.

3 Digital Resources

While digital resources play a central role in digital innovation (Henfridsson et al. 2018) the literature stops short of providing a first principled definition of the digital resource construct. One that draws on previous IS research, while identifying critical differences between the traditional conceptualization of IT resources and digital resources (Kohli and Grover 2008; Lusch and Nambisan 2015).

In line with IS research, we define resources as "assets and capabilities that are available and useful in detecting and responding to market opportunities or threats" (Wade and Hulland 2004, p. 109). Assets are "anything tangible or intangible the firm can use in its processes for creating, producing, and/or offering its products (goods or services) to a market" while capabilities are "repeatable patterns of actions in the use of assets to create, produce, and/or offer products to a market" (Wade and Hulland 2004, p. 109). IT assets are typically hardware and software (e.g., IT infrastructure, information repositories), whereas IT capabilities stem from organizational competencies (e.g., IS-business partnership, software development skills). While this focus was appropriate in a context dominated by "IT boxes," with the increasing pervasiveness of digitalization (Tilson et al. 2010; Yoo et al. 2010), *digital resources* are emerging as a key construct for explaining "digital phenomena" (Henfridsson et al. 2018). Digital resources are a specific class of digital objects that a) are *modular*, b) *encapsulate objects of value*, either assets or capabilities, c) that are accessible by way of a *programmatic bitstring interface*. We devote the remainder of this section to clarifying and supporting this definition. We do so by first reviewing the ontology of digital objects, and then exploring the ontology of digital resources in order to clarify their differences with traditional IT resources.

3.1 Digital Objects

An object is an enduring, structured collection of elements. They are comprised of distinct components, objects themselves, organized in a discernible arrangement (Faulkner and Runde 2019). Objects can be grouped in two distinct sets: material and nonmaterial. This classification depends on whether they exhibit spatial attributes, like volume or mass. Thus, while the touch screen of an iPhone is a material object, the phone's iOS operating system is a nonmaterial object. Hybrid objects, a subset of material objects, are comprised of both material and nonmaterial elements (e.g., a working iPhone running iOS).

Bitstrings, a type of nonmaterial object, are "the sequences of 1's and 0's used in computing to represent information in binary form" (Faulkner and Runde 2019, p. 804). Bitstrings, separated in program files and data files, occupy a central role in digital computing. By way of encoding and inscription, bitstrings assume the role of bearer of other nonmaterial objects (Faulkner and Runde 2013). This ability to bear nonmaterial objects of value "is arguably the single most important feature of the

bitstring [leading to the conclusion that] the demand for bitstrings is a derived one, arising from demand for the nonmaterial object inscribed into a bitstring, rather than for the bitstring itself, and where multiple layers of nonmaterial bearer may exist between the bitstring and the ultimate object of value" (Faulkner and Runde 2019, p. 1293). This property results in a layering of nonmaterial bearers such that the object of value is far removed from the ultimate physical bearer. In other words, while ultimately requiring a physical carrier (e.g., a solid-state drive), nonmaterial objects are increasingly inscribed into layers of bitstrings that abstract further and further away from the constraints of the physical bearer.

3.2 Environmental Context of IT x versus Digital x

While ontologically sound and built from first principle theorizing, the original definition of digital objects does not allow for a differentiation between IT phenomena and digital phenomena. The above ontological arguments consider any hardware/software system rooted in the Von Neumann digital computer architecture and the stored program concept (Von Neumann 1945) as a digital object. Replacing the traditional IT "x" concepts presents an opportunity to create improved conceptual clarity that considers the distinctive characteristics of novel digital phenomena. In the remainder of this section we show that, broadly speaking, digital phenomena occur in an environmental context that is *infrastructural*, *combinatorial* and *servitized*.

a) Infrastructural: IT has left the boundaries of corporations to permeate virtually any aspect of society, in large part thanks to the Internet (Hanseth and Lyytinen 2010). Localized and bounded IT infrastructures increasingly give way to digital information infrastructures – "unbounded, evolving, shared, heterogeneous, and open installed bases of capabilities" (Tilson et al. 2010, p. 754) configured as "evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities" (Hanseth and Lyytinen 2010, p. 4). The above definition highlights the recursive and shared nature of digital information infrastructures. They are socio-technical artifacts (Silver and Markus 2013) that are comprised of similar elements that non-exclusively contribute to the functioning of other information systems (Henfridsson and Bygstad 2013).

b) Combinatorial: Technological progress stems from the combination and recombination of evolving elements components into new structures, leading to a constant state of combinatorial technology evolution (Arthur 2009). An important driver of combinatorial evolution in technology is the availability and variety of elements that serve as the "building blocks" of new structures such that "the more there is to invent with, the greater will be the number of inventions" (Arthur 2009, p. 21). In the information systems context, modules are digital objects characterized by varying degrees of openness and unboundedness (Yoo et al. 2010). To the extent that the interfaces of digital objects do not share assumptions or data with a specific design hierarchy (i.e., they are unbounded), and they are amenable to address unexpected tasks (i.e., they are open), the resulting components become available to organizations that can easily integrate them into novel recombinations (Clark 1985; Yoo 2013).

c) Servitized: While the combinatorial nature of digital phenomena pertains to their nature as digital objects, servitization captures the managerial and contractual characteristics of digital phenomena. The technical aspects of artifact design (e.g., design rules and task structure) are accompanied by a contract structure, explicit or implicit, that provides the framework for possible activities (Baldwin and Clark 2000). Such contract structure must fit the task structure underlying the design and production processes of the firm's outputs. Servitization represents the contractual availability of resources as services, rather than assets. Recent research on digital platforms has discussed the role of boundary resources in governing the interactions between the platform and its users (Eaton et al. 2015). Generalizing from this early work we note how servitization is a direct implication of the ontology of digital objects in that these elements of the information infrastructure are shared open and unbounded (Yoo et al. 2010), but they are also highly abstracted. However, the defining characteristic of servitization is not in the nature of what is being servitized. Rather servitization is about the codification and inscription of the contract structure into bitstrings. The result is that relationship and governance is dynamic and agile, enabling organizations that engage in combinatorial evolution to obtain the service on an as needed basis and to pay for it on a consumption basis. The ability to encode into bitstring the contract structure represents a fundamental shift compared to traditional intra- or

inter- organizational IT systems (Rai et al. 2006) where both governance and technical agreements required lengthy negotiations and ad-hoc formal agreements.

3.3 Digital Resources

We conceptualize digital resources as a specific class of digital objects that a) are *modular*, b) *encapsulate objects of value*, either assets or capabilities, c) that are accessible by way of a *programmatic bitstring interface*. Digital resources leverage the primary characteristics of the bitstring: the capacity to bear objects of value, either assets or capabilities. Digital assets encapsulate nonmaterial or hybrid objects borne by bitstrings. Digital capabilities encapsulate competencies borne by bitstrings. As a consequence, digital resources are nonmaterial objects in their own right, divorced from their physical bearers. One of the defining characteristics of digital resources is their modularity. As any modular component enforcing the information hiding principle (Parnas 1972), digital resources abstract the details of their inner working and restrict points of interactions with other resource to their interface. Thus, the interface is the "preestablished way to resolve potential conflicts between interacting parts of the design" (Baldwin and Clark 2000, p. 73) and with each new layer of abstraction, the complexity of previous technological evolutions (Arthur 2009) is "hidden away" into a new module (Baldwin and Clark 2000). In the case of digital resources, the potential conflicts handled by the interface and its design pertain to both the technical and governance decision space. As shown by the proponent of modularity theory, the technical aspects of artifact design (e.g., design rules and task structure) are accompanied by an explicit or implicit contract structure, that provides the framework for activities within the design hierarchy (Baldwin and Clark 2000). It follows that a defining characteristic of digital resources is the design and structure of their interface as a *programmatic bitstring interface*. It is the bitstring nature of the interface, we argue, that warrants referring to this class of digital objects with the new label of *digital resources*.

Consider digital payment processor Stripe. The firm exposes a set of digital resources that enable developers to plug a payment module into their applications. In the context of DSIs, Stripe exposes digital capabilities because it encapsulates objects of value, the ability to programmatically process payments, as a modular component, accessible through a digital interface. Stripe's digital capabilities are not only modular

and accessible by way of a programmatic bitstring interface instantiated as a set of APIs that regulate both the technical and governance aspects of resource utilization. But they are also portable, a special case of digital resource, because Stripe provides the translator modules, in the form of client-side libraries that developers must import into their own applications, to make requests to the Stripe API. Stripe offers translator modules in the most widely used programming languages (i.e., Ruby, Python, PHP, Java, Node, .NET) in order to make its digital capabilities widely portable and product agnostic. As such, they are leveraged for process payments in different design hierarchies (e.g., website, iPhone app, Amazon Echo skill).

In summary, digital resources are *structurally different* from IT resources as originally conceptualized. Where IT resources where categorized as either technical, like IT infrastructure or business applications (Melville et al. 2004), or managerial, like technical IT skills or IT management skills (Wade and Hulland 2004), digital resources are socio-technical artifacts. Their technical characteristics as well as their contract structure are embedded into the digital object and interface. Note as well that digital resources could not exist outside of their infrastructural, combinatorial and servitized digital environment. This context provides the "terroir" necessary for digital resources to emerge, develop and be harvested into value creating DSIs.

4 Digital Strategic Initiatives: Two Illustrations

With a clear definition of digital resources as the building blocks of DSI, we identify two different approaches to the execution of Digital Strategic Initiatives (DSI). As noted above, DSIs are identifiable competitive moves that depend on the use of digital resources to create and appropriate economic value. It follows that there are two pathways to DSI value creation: a) orchestration of digital resources and b) creation of novel digital resources. The first consists in leveraging existing digital resources and recombining them in a novel value creating proposition (Henfridsson et al. 2018). The second consists in building a valuable digital resource around unique objects of value that can be made available to external organizations by way of a programmatic bitstring interface. We provide two illustrations that are presented as "pure exemplars" for illustrative purposes.[2]

[2] The two cases are not intended to be rigorous analyses of the two DSI archetypes. Rather, they are illustrations aimed at clarifying the definition of DSI and at providing examples of digital resources.

a) Instacart focuses on grocery delivery intermediation, enabling customers to select items from about half a billion listings across twenty thousand locations and have the order delivered to their door under two hours. The analysis will show how a DSI like Instacart grocery delivery relies on a complex blend of digital resources, traditional IT assets and capabilities, as well as complementary resources (see Table 1). Digital resources are core to the initiative's success, in the sense that the initiative could not be feasibly executed without them.
b) Cloud Kitchens is a provider of "smart kitchens" that are optimized for delivery only restaurants. Cloud Kitchens enable restaurateurs to pay for the space as they go, with contracts as short as one month. The kitchen infrastructure is a physical asset that is rented to the restaurateur, who is able to customize it and configure it with specialized equipment her restaurant concept requires. But Cloud Kitchens develops and offers an array of digital resources that a restaurateur can orchestrate, along with their cooking and management skills, into a value proposition of food delivery.

Table 1: Examples of resources orchestrated by Instacart and created by Cloud Kitchens

Firm	Resource	Type	Description
Instacart	Grocery catalog	IT Asset	Digital representations of 500,000,000 grocery items (price, name, image), from over 20,000 supermarkets. Data is compiled from grocers and is owned by Instacart.
Instacart	Maps	Digital Asset	Instacart incorporates maps exposed by Google in its shopper and customer apps.
Instacart	Cloud-first Development	IT Capability	Instacart developed custom predictive models to make millions of item listings easily browsable at scale. To do so it leveraged AWS Elasticsearch, and historical purchase data.
Instacart	Payment processing	Digital Capability	Instacart collects money from the customer and immediately pays the grocery stores, handling any adjustments, refunds or discounts. It integrates payment processing capabilities exposed by Stripe.
Instacart	Fraud prevention	Digital Capability	Instacart ensures the use of legitimate credit cards. It integrates a fraud prevention capability exposed by Sift.
Cloud Kitchens	Online order processing	Digital Capability	Cloud Kitchens enables restaurateurs to receive delivery orders from major food delivery platforms (e.g., Deliveroo). Orders are consolidated and integrated into one order flow for the kitchen.
Cloud Kitchens	Food delivery	Digital Capability	Cloud Kitchens exposes food deliver capabilities to its tenants by relying on partnerships with food delivery platforms.

Table 1 lists some of the characterizing resources in the Instacart and Cloud Kitchens cases. In the case of Instacart, an orchestration type DSI, we identify and describe IT resources and digital resources – both assets and capabilities. For Cloud Kitchens we identify and describe two digital capabilities the firm creates and makes available to its restaurant customers.

5 Discussion and Conclusions

The two examples of DSI illustrate how such initiatives are enabled by the infrastructural, combinatorial and servitized competitive environment that fosters the development and feasible use of digital resources. Contrast Instacart with a firm that aimed to provide the same value proposition in 1996: Webvan. Webvan, the largest failure of the dot-com era, closed its doors in June 2001 after spending over $1.2 billion in funding. In order to provide home delivery, Webvan had to hire drivers, build warehouses, purchase trucks, write custom made software for customer ordering and order fulfillment, buy servers and run their IT infrastructure in dedicated datacenters. Conversely, Instacart could leverage the existence of a digital information infrastructure that includes a full stack of networking hardware and communication protocols enabling real-time data exchange and mobile devices in the hands of customers and freelance shoppers. Whereas Webvan had to purchase a fleet of trucks, hire drivers and grocery pickers, a fixed cost investment (McAfee 2002). Instacart relies on freelance "shoppers" who work self-scheduled flexible hours and receive variable pay depending on the number of deliveries executed. For technology infrastructure, Instacart relies on Amazon Web Services (AWS) RDS storage and the EC2 computing. In other words, Webvan had to custom develop an integrated technology infrastructure and use internal resources to offer its value proposition. Conversely, Instacart orchestrates digital, IT and complementary resources relying on the ability to access them services built upon an underlying shared, open infrastructure and recombine them into a cohesive value proposition (i.e., two-hour grocery delivery).

The two examples also illustrate how digital resources differ from the traditional conception of IT resources. While not negating the existence and value of traditional IT assets and capabilities, the cases show how digital resources differ in their structure and composition. Digital resources are cohesive wholes (i.e., modules) that can be readily recombined with other technology or complementary resources by

connecting through a digital interface. For example, a restaurant that leverages the Cloud Kitchens online ordering digital capability would interface its independent or intermediated ordering presence (e.g., Deliveroo) with the Cloud Kitchens module and receive orders for preparation and delivery. Similarly, Instacart leverages Stripe's fraud prevention capability by integrating it with its app via Stripe's API.

The premise of this paper is that information systems research is best positioned to contribute to our collective understanding of value creation and appropriation in the digital era. The discipline has accumulated a wealth of knowledge about the strategic role of information systems, and such knowledge is instrumental in understanding how digital strategic initiatives can be *designed*, *implemented* and *sustained* over time. Yet, given the proliferation of digital "x" constructs that parallel well-established IT "x" ones, it is critical to surface the difference between IT phenomena and digital phenomena. We believe this is even more important at this time when the emergence of digital "x" labels run the risk of diluting the core of information systems literature and its potential influence on organizational and business research. To the ongoing discourse we contribute a precise definition of key constructs: digital strategic initiatives and digital resources, and an illustration of two different approaches to the execution of digital strategic initiatives: a) orchestration of digital resources and b) creation of novel digital resources.

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IT'S COOL! ANALYSIS OF FACTORS THAT INFLUENCE SMART THERMOSTAT ADOPTION INTENTION

STANISLAV MAMONOV[1] & MARIOS KOUFARIS[2]

[1] Montclair State University, Montclair, United States of America, e-mail: stanislav.mamonov@montclair.edu
[2] Baruch CUNY, New York, United States of America, e-mail: marios.koufaris@baruch.cuny.edu

Abstract Smart thermostats represent an innovative smart home technology and a growing commercial opportunity, yet little is known about the salient factors that affect the adoption of such devices. To address this gap in research, we conduct a three-stage study that progresses through belief elicitation, exploratory factor analysis and confirmatory factory analysis within a nomological network. We leverage the mixed methods approach to explore the factorial structure of salient perceived benefits and concerns associated with smart thermostats, and we examine the effects of the emergent factors on the adoption intention. We discover that a novel factor, which we term techno-coolness, is the key predictor of the smart thermostat adoption intention. Techno-coolness encompasses the perceptions that a smart thermostat can make a home look modern and futuristic, be fun to use, and make the user feel technologically advanced. We also find that compatibility concerns as well as privacy concerns are significant impediments to the smart thermostat adoption intention.

Keywords: smart home, technology adoption, mixed-methods research, smart thermostat, analysis of factors.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.5
ISBN 978-961-286-362-3

1 Introduction

Continued advances in information and communication technologies have led to the continuous introduction of different types of smart home technologies (SHTs). SHTs span a very broad range of innovative products that can provide security and access controls, home healthcare, smart kitchen and home appliances, as well as self-learning heating and cooling systems, among others (Markets and Markets, 2017)(Markets and Markets, 2017). Industry estimates suggest that smart home technologies will represent a $137 billion market opportunity by 2023 (Markets and Markets, 2017). Despite the practical importance of this market, there has been relatively little academic research on the factors that influence SHT adoption.

Smart thermostats are an important type of device in the smart home ecosystem because they promise to simultaneously accomplish the dual goals of 1) improving the home experience through adaptive temperature regulation and 2) reducing energy expenditures through optimization of the home heating and cooling systems. The commercial market for smart thermostats is expected to reach $5.9 billion by 2020 (Markets and Markets, 2017)(Markets and Markets, 2015). Prior research on smart home technologies has been largely done outside of the United States and limited to the application of TAM and UTAUT theories (Park, Kim, Kim, & Kwon, 2018; Wang, McGill, & Klobas, 2018; Yang, Lee, & Zo, 2017). Little is known about the *salient* factors that affect the adoption of smart thermostats and similar technological artifacts. We begin to address this knowledge gap in this study. Responding to calls for context-specific theory development (Hong, Chan, Thong, Chasalow, & Dhillon, 2013), we conduct a three-stage study that progresses through elicitation of salient perceived benefits and concerns associated with smart thermostats, exploratory factor analysis (EFA) of the elicited perceived benefits and concerns, and confirmatory factor analysis (CFA) within a broader nomological network, wherein we evaluate the effects of the emergent constructs on the smart thermostat adoption intention.

We find that a new construct, which we term *techno-coolness*, is the key predictor of the smart thermostat adoption intention. *Techno-coolness* captures the perceptions that a smart thermostat can make a home look modern and futuristic, be fun to use, and make the user feel technologically advanced. We also find that security and privacy concerns, as well as concerns about the smart thermostat compatibility with the

existing heating and cooling systems, are the salient factors that negatively affect smart thermostat adoption intention.

Our core theoretical contribution is the identification of t*echno-coolness* as the key predictor in the adoption of novel smart home technologies. *Techno-coolness* expands the list of technology-related constructs that need to be considered in the context of individual voluntary novel technology adoption and it complements the extant literature that highlights the utilitarian and hedonic motives in technology adoption (Venkatesh, Thong, & Xu, 2012). The key practical implication of our study is the importance of *techno-coolness* perceptions over the functional benefits in the adoption of smart home technologies. Smart home technologies that merely provide functional benefits may fail to win user acceptance if they do not enhance perceptions of *techno-coolness*.

2 Theoretical background

2.1 Smart home related research

A smart home is defined as "a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security, and entertainment through the management of technology within the home and connections to the world beyond" (Aldrich, 2003). Smart home technologies include sensors, monitors, interfaces, appliances, and other types of connected devices.

Much of the research on the adoption of SHTs has focused on the home healthcare applications for the elderly. A number of studies conducted focus groups and surveys with the elderly to assess the perceived benefits and concerns associated with in-home monitoring technologies: portable blood pressure monitors, fall sensors, cameras, etc. (Coughlin, D'Ambrosio, Reimer, & Pratt, 2007; Courtney, 2008; Demiris, Hensel, Skubic, & Rantz, 2008; Townsend, Knoefel, & Goubran, 2011). The consensus that emerges from these studies is that older adults generally view their homes as sanctuaries and they are concerned about the loss of autonomy that may result from the installation of monitoring technologies (Ziefle, Röcker, & Holzinger, 2011). Although the elderly appreciate the potential benefits offered by in-home monitoring technologies, they generally express concern over the loss of

privacy associated with the monitoring technology use (Liu, Stroulia, Nikolaidis, Miguel-Cruz, & Rincon, 2016).

In a parallel stream of research, smart energy meters that can support centralized energy distribution control and help alleviate the electric grid load during peak times have received attention in electrical engineering and energy policy research (Arif et al., 2013; Palensky & Dietrich, 2011). A recent survey of UK residents revealed that energy savings and added convenience were the highest rated benefits expected from SHTs (Wilson, Hargreaves, & Hauxwell-Baldwin, 2017). However, the survey also showed that residents are wary of overreliance on technology.

Security and privacy concerns have been repeatedly raised in relation to smart meter adoption (Efthymiou & Kalogridis, 2010; Sankar, Rajagopalan, & Mohajer, 2013). An engineering analysis of smart meters substantiated the legitimacy of privacy concerns. The analysis of encrypted information transmission patterns from smart meters showed that it is possible to infer appliance usage patterns even without knowing the content of the communications (McKenna, Richardson, & Thomson, 2012).

In summary, some of the prior research on SHTs has been narrowly focused on in-home monitoring devices for the elderly and electric smart meters. The common observations across these contexts suggest that SHT adoption involves weighing perceived functional benefits against the potential loss of privacy and possibly a sense of autonomy. In the next section, we review the key research studies on technology adoption across a broader set of contexts.

2.2 Technology adoption

Factors influencing technology adoption are a central theme in Information Systems research (Venkatesh et al., 2012; Venkatesh, Thong, & Xu, 2016). The Technology Acceptance Model (TAM) laid the foundation for much of the research in this domain (Davis, 1989). TAM draws on the theory of reasoned action (TRA) (Fishbein, 1979) and it posits that technology performance expectancy (perceived usefulness) and perceived effort expectancy (perceived ease of use) are the key determinants that influence the technology adoption intention.

Although TAM and UTAUT have proven their value across different technology adoption domains (Venkatesh, Bala, & Sambamurthy, 2016), a number of studies have demonstrated that alternative theoretic perspectives are better at uncovering the key factors that influence technology acceptance in specific contexts. For example, Hsiao (2003) showed that *fear* and *distrust* were the key factors that helped explain the adoption intention in an e-marketplace. Brown and Venkatesh (2005) found that *perceived usefulness for others* (children) had a significant effect on home computer adoption. Baird et al. (2012) demonstrated that a complex set of *contingencies* influenced the adoption of electronic patient portals by healthcare providers. In summary, although TAM and its successor, UTAUT, offer general frameworks encompassing factors that can influence the technology adoption intention, research within specific contexts has found that context-specific factors afford a better, more contextualized understanding of the phenomenological drivers in the respective contexts.

3 Methodology

Following the calls for context-focused research in information systems (Hong et al., 2013) and in recognition of the novelty of smart home technologies that may pose challenges for generic theoretical models being able to capture the key contextual factors that influence technology adoption in this domain, we draw on theory of reasoned action as the overarching theoretical framework and we conduct a three-stage study. Our analysis proceeds through three stages: Stage 1- elicitation of salient perceived benefits and concerns associated with smart thermostats, Stage 2 - exploratory factor analysis, and Stage 3 – confirmatory factor and nomological network analysis.

For each stage in the study, we recruited a new set of participants using Amazon's Mechanical Turk (AMT). AMT is an online labor market for micro tasks that has received support as a valuable source of research participants across disciplines (Buhrmester, Kwang, & Gosling, 2011; Feild, Jones, & Miller, 2010; Holden, Dennie, & Hicks, 2013; Kittur, Chi, & Suh, 2008; Lowry, D'Arcy, Hammer, & Moody, 2016). To avoid potential cross-cultural effects, we limited the participation to AMT "workers" from the United States. We relied on Qualtrics, a commercial survey platform, to capture the participants' responses to our surveys in each stage of the study.

For Stage 1, we recruited 24 participants from AMT. We collected basic participants' demographic data and we asked the participants to indicate ownership of different smart home technologies. None of the participants in this stage indicated ownership of a smart thermostat. We exposed the participants to a 5-minute video describing smart thermostats. We then asked the participants to share their opinion on the top 5 potential benefits and top 5 concerns associated with smart thermostats. Based on the content analysis of the themes that emerged in Stage 1, we generated items that reflect frequently mentioned perceived benefits and concerns.

In Stage 2, we recruited a new group of 150 participants from AMT. We collected their basic demographic information and we exposed the participants to the same video describing smart thermostats. We then asked the participants to indicate their agreement or disagreement with the items that were generated in Stage 1. We used 7-point Likert scales anchored in "1 – Strongly agree" and "7 – Strongly disagree". We performed exploratory factor analysis using SPSS version 25 using oblimin factor rotation to account for potential correlation among the emergent constructs. In Stage 2, we inductively developed a list of latent constructs that captured the themes that emerged from the analysis.

In Stage 3, we recruited a new group of 625 participants from AMT. We collected their basic demographic information and we exposed the participants to the video describing smart thermostats. We surveyed the participants on the constructs that emerged in Stage 2. We measured their adoption intention using the established scale from UTAUT2 (Venkatesh et al., 2012).

4 Results

4.1 Stage 1 – Perceived benefits and concerns elicitation

Based on the elicited perceived benefits and concerns, we developed a list of 68 items that reflect commonly stated perceived benefits and concerns. The items included such statements as "A smart thermostat will help me save money on electricity," "A smart thermostat will make my home more modern," and "A smart thermostat can be hacked."

4.2 Stage 2 – Exploratory factor analysis

We conducted an exploratory factor analysis following the recommendations of Treiblmaier & Filzmoser (2010). We performed principal axis factor analysis with oblique rotation using SPSS version 25. We chose to use the oblique rotation to allow for potential correlations among the latent constructs reflected in the responses to individual survey items. We relied on two criteria to determine the number of factors to retain. First, we examined the scree plot. Second, we performed parallel analysis by comparing individual factor eigenvalues against a set of simulated eigenvalues given the parameters in our study (Hayton, Allen, & Scarpello, 2004). This approach has been shown to avoid potential under and over factor specification in EFA.

The exploratory factor analysis is an established methodology for "identifying the underlying dimensions of a domain of functioning" in management, marketing, psychology, and information systems research (Fabrigar, Wegener, MacCallum, & Strahan, 1999; Hurley, Scandura, Schriesheim, & Brannick, 1997; Mamonov & Benbunan-Fich, 2017; Stewart, 1981). Following the recommendations of Fabrigar et al., (1999), we examined the content of individual constructs to develop a theoretical foundation for the latent factors that can affect the adoption of smart thermostats.

Due to manuscript length constraits, we present a very abbreviated summary of the exploratory factor analysis here. We found several well established factors (performance expectancy, effort expectancy, information privacy and security concerns and cost concerns), as well as more context-specific factors (installation, fragility and compatibility concerns) in our analysis. We also uncovered a novel factor that captures beliefs related to potential of smart thermostats to make the users feel "technologically advanced" and "up to date" while also making the homes feel more modern and futuristic. Such potential effects of technology have been discussed in individual psychology literature that focused on what makes some consumer products *cool* (Bruun, Raptis, Kjeldskov, & Skov, 2016; Culén & Gasparini, 2012). Following this stream of research, we term the factor *techno-coolness*.

Item analysis of the *techno-coolness* factor suggests that it captures a complex set of benefits that the technology users expect to derive through the product use. On the one hand, adoption of the technology promises to transform the esthetic appearance of one's home by making it "more modern" and "technologically advanced". On the other, the potential adopters expect to derive personal image benefits ("A smart thermostat in my home would make me feel like I was making the most out of newer technology") and experience joy while using it. The emergent complex structure of techno-coolness is consistent with prior conceptions of *cool* products that are expected to serve a broad spectrum of individual goals, including self-presentation, mastery, fun, and innovativeness (Culén & Gasparini, 2012).

Stage 3 – Confirmatory factor and nomological network analysis

In the third stage we recruited 625 new participants from AMT. Thirteen responses were excluded because the participants failed to answer the attention control questions correctly or there was evidence of a common response bias, leaving us with a sample of 612 usable responses.

Following the recommendations of Gefen et al. (2011) on theory development, we relied on PLS for data analysis using SmartPLS version 3 software. PLS analytical method relies on iterative estimation of item loadings on the latent factors and the correlations between the latent factors. Our presentation of the results follows the latest recommendations on PLS reporting in Hair Jr et al. (2016).

In the first step of the analysis, we assessed the discriminant validity of the measurement model. All items had loadings above 0.7 on the respective constructs and below 0.5 on all other constructs indicating good discriminant validity. We are not showing the item loadings here due to the manuscript length constraints. Next, we evaluated measurement reliability. Cronbach's alphas are above 0.87, rho values are above 0.7 and composite reliability scores are above 0.85 for all scales in our instrument indicating good measurement reliability. Average variance extracted (AVE) is above 0.7 and the square root of AVE is higher than any inter-construct correlation. Table 1 summarizes the reliability and discriminant analysis results.

Table 1: Measurement reliability and discriminant validity analysis

	CA	RH	CR	AI	CC	CO	EE	PE	IC	PC	RC	TC
Adoption Intention (AI)	0.97	0.97	0.97	0.96								
Compatibility concerns (CC)	0.90	0.92	0.91	-0.33	0.87							
Cost concerns (CO)	0.93	0.98	0.93	-0.31	0.36	0.89						
Effort Expectancy (EE)	0.87	0.90	0.85	-0.25	0.39	0.19	0.72					
Performance expectancy (PE)	0.97	0.97	0.97	0.43	-0.19	-0.20	-0.12	0.94				
Installation concerns (IC)	0.96	0.99	0.96	-0.18	0.44	0.30	0.51	-0.10	0.93			
Privacy concerns (PC)	0.98	0.98	0.97	-0.26	0.24	0.17	0.15	-0.07	0.17	0.87		
Reliability concerns (RC)	0.90	0.92	0.91	-0.33	0.27	0.32	0.39	-0.21	0.42	0.28	0.88	
Techno-coolness (TC)	0.92	0.93	0.92	0.55	-0.07	-0.21	-0.09	0.56	-0.01	-0.13	-0.22	0.79

CA – Cronbach's alpha, RH – rho, CR – composite reliability, average variance extracted (AVE) is shown in the diagonal.

In the next step, we examined the relationships between the constructs that represent different smart thermostat related perceived benefits/concerns and the adoption intention by running the bootstrapping procedure. We found that *performance expectancy* ($\beta = 0.14$, $p<0.05$) and techno-coolness ($\beta = 0.36$, $p<0.001$) are positively correlated with the adoption intention, whereas *compatibility concerns* ($\beta = -0.17$, $p<0.01$) and *privacy concerns* ($\beta = -0.12$, $p<0.05$) are negatively correlated with the adoption intention indicating that these factors have negative effects on the adoption intention. *Effort expectancy*, *installation concerns*, *reliability concerns* and *cost concerns* are not significantly correlated with the adoption intention. Among the control variables, only income is statistically significantly negatively correlated with the adoption intention ($\beta = -0.20$, $p<0.01$). The results are summarized in Figure 1.

5 Discussion

In this study, we sought to uncover salient user beliefs that can affect the adoption of smart thermostats as an example of a commercially important smart home technology. Through progressive steps of belief elicitation, exploratory and confirmatory factor analysis, and nomological network analysis, we uncovered eight

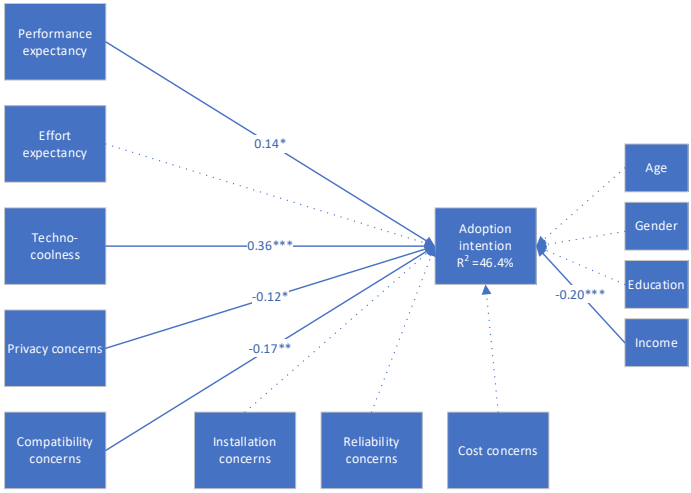

Figure 1: Structural model analysis

salient factors that may affect smart thermostat adoption intention. Among the eight factors, *performance expectancy* and *privacy concerns* are two well-known factors in technology adoption research (Venkatesh, Thong, et al., 2016) We found that *performance expectancy* and *privacy concerns* have countervailing effects on the smart thermostat adoption intention, though these effects are relatively minor. *Performance expectancy's* effect size is 0.02 and *privacy concerns'* effect size is 0.024. We discovered that a novel factor, which we termed *techno-coolness*, has the largest effect size on the smart thermostat adoption intention (f^2 =0.164). We also found that *compatibility concerns* had the second largest effect size of 0.036. While the users shared a number of additional concerns during the elicitation stage of our study: *effort expectancy*, *installation concerns*, *reliability concerns*, and *cost concerns*, these concerns did not have a statistically significant effect on the adoption intention in our nomological network when we surveyed a broader sample in stage 3 of our study. Overall, the factors in our model explain 46.4% of variance in the adoption intention, suggesting that we captured the core factors that influence the adoption intention in this context.

Our study makes a number of contributions to theory. First, we uncover *techno-coolness* as a novel construct that can significantly affect the adoption of innovative technologies. *Techno-coolness* is a multi-dimensional construct. It captures the technology capacity to 1) make the person feel more technologically savvy, 2) make the person and/or the person's environment "look good" and appear more modern,

and 3) be fun to use. The complex dimensionality of *techno-coolness* likely emerges from the complex motives that underlie the consideration of adopting innovative smart home technologies. Studies on general product *coolness* suggest that *cool* products satisfy a complex set of individual goals that may include accomplishment, connection with others, identification development and sensory experiences (Holtzblatt, 2011). The complex dimensionality of *techno-coolness* is also consistent with prior attempts to develop general measures for *cool* consumer products that noted that general *coolness* may be reflected in product attributes (original, fresh, unique, distinct, hip), the subculture associated with the product use (unique and different), and product utility (Sundar, Tamul, & Wu, 2014). At the same time, *techno-coolness* is clearly distinct from general product *coolness* in that it captures the association between technology that is being perceived as innovative/modern/futuristic and the expected personal image and utility benefits associated with the innovative technology use. Marketing research has noted that some retro consumer products can be *cool* (Culén & Gasparini, 2012). It is unlikely that older technology can be perceived as *techno-cool*.

Our second theoretical contribution is the development of context-specific factors that may affect smart thermostat adoption. In addition to *techno-coolness* being the most significant factor in our model, the second most important factor is *compatibility concerns*. *Compatibility concerns* have been noted as an important consideration in technology adoption in the past (Agarwal & Prasad, 1998; Cooper & Zmud, 1990), but they are infrequently considered in the more recent research (Venkatesh, Thong, et al., 2016). Successful smart thermostat adoption requires interoperability with the existing heating and cooling systems. Our results reveal an important consideration that likely affects many other smart home technologies.

Our study also has a number of implications for practice. First, the results of our study suggest that functional benefits afforded by smart home technologies may not be the key reason why people would consider buying them. *Techno-coolness* is the key factor that affects the smart thermostat adoption intention in our study. Therefore, consideration of *techno-coolness* has to be an essential step in smart home technology development. If it is not *techno-cool*, it may be not be adopted. The second insight for practice emerges from the fact that our elicitation of concerns associated with smart thermostat adoption produced a range of concerns including general effort expectancy in learning how to operate the device, installation and reliability

concerns, and concerns about the high cost of technology. Rather surprising, we found that most of the concerns had no effect on the smart thermostat adoption intention. These results suggest that even though users may voice many concerns in product evaluation, these concerns may not affect their adoption intention.

Lastly, we should note that no research is without limitation and our study is not an exception. While we sought to recruit a diverse group of participants for all stages of our study, the AMT subject pool may not represent the larger population, and further research would be required to confirm the applicability of the results in our study within the broader population. Further, we limited the participation in our study to only AMT subjects based in the United States. It is likely that the cultural context will be an important factor on the consideration of smart home technology adoption in different countries. Further research would be required to explore the cultural factors that may play a role in smart home technology adoption.

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RegTech Opportunities in the Platform-Based Business Sector

Roger Clarke[1,2]

[1] Xamax Consultancy Pty Ltd, Canberra; UNSW Law, Sydney, Australia, e-mail: Roger.Clarke@xamax.com.au
[2] Research School of Computer Science, Australian National University, Canberra, Australia, e-mail: Roger.Clarke@xamax.com.au

Abstract The notion of RegTech has emerged in recent years, but its application appears to have been mostly limited to the use of technology to assist with organisations' compliance with regulatory requirements. A model is presented that encompasses RegTech's full scope, embracing its capacity to address the needs not only of regulatees, but also of regulators and the intended beneficiaries of regulatory regimes. The model is then applied to the recently-popularised platform-based business model, whose mature form is evidenced by Uber and Airbnb. A range of opportunities is identified for practitioners and researchers to contribute to the application of information technologies in the regulatory space.

Keywords: regulation, FinTech, RegTech, infrastructural regulation, uber.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.6
ISBN 978-961-286-362-3

1 Introduction

The term 'RegTech' emerged in 2015 to refer to technologies supporting regulatory processes. Reflecting its origins as a variant of FinTech, the main interest has initially been within financial services corporations. It has also been viewed narrowly from the perspective of those organisations, and hence the emphasis has mainly been on compliance aspects.

The conference theme for the Bled eConference in 2020 is 'Enabling Technology for a Sustainable Society'. Organisations generally, but especially in the private sector, have their focus on the short term. As a result, sustainability issues are beyond their horizon. Sustainability is therefore dependent on interventions by other parties, especially parliaments, policy agencies and regulatory agencies whose function is to address externalities and protect public good interests. Researchers, particularly those funded from the public purse, have an obligation to not just reflect the interests of the for-profit corporations that drive economic progress, but to also conduct research that contributes to the sustainability of the economy, society and the environment (Clarke & Davison 2020). For researchers into applications of IT, that obligation translates into the need to consider RegTech's broader application.

This paper accordingly encompasses not only compliance applications but also RegTech's potential to serve the interests of regulators, and of beneficiaries of regulatory schemes. Previous work has developed a framework whereby IS professionals and academics can properly understand regulatory regimes, can identify opportunities for the development and deployment of RegTech, and can conceive, design and deliver appropriate technological support to relevant organisations. The purpose of this paper is to briefly present that framework and to demonstrate its efficacy by applying it to one particular and very topical form of business.

The platform-based business model has been much-discussed in recent years, and the Airbnb and Uber approaches have generated particular excitement. The model is a variant of the longstanding notion of 'marketspace' (Rayport & Sviokla 1994, Clarke 2001). I adopt here the approach of Taeuscher & Laudien (2018), who propose four defining features of a platform-based digital marketplace (p.320):

- digital marketplaces connect independent actors from the demand and supply sides via a digital platform;
- these actors enter direct interactions with each other to initiate and fulfil commercial transactions;
- the marketplace platform provides an institutional and regulatory frame for transactions; and
- the platform does not substantially produce or trade goods or services itself.

The large majority of the academic literature on platform-based corporations is concerned with business strategy, business models, and the application and exploitation of Internet, Web and mobile technologies to achieve the aims of that corporation, subject to the constraints of adequately reflecting the interests of the actors on the demand and supply sides. The focus here, however, is primarily on the regulation of the behaviour of platform-based corporations, in order to satisfy the interests of other parties. Those parties include not only platform users, but also other entities that are affected by the platform's operations, industry sectors and segments as represented by industry and consumer associations, government policy agencies, and organisations that perform regulatory functions in relation to the relevant marketplace.

This paper commences by reviewing RegTech's origins and nature. An assessment is provided of the literature that has emerged during the first few years since the term was coined. A framework is then presented for studying the field of regulation and the opportunities for technology to support it. Characteristics of platform-based business models are discussed, and the framework for RegTech research applied to such models in order to identify opportunities and provide insights into the framework's value.

2 RegTech

The term 'RegTech' appears to have been first published in a UK Government report of March 2015 on financial technologies (UKGOS 2015), sometimes referred to as 'the Blackett review'. The earliest occurrence found using Google News is a single, fleeting mention in an article on the UK Budget (Glick 2015). The earliest mentions found by Google Scholar are Arner et al. (2015) and Treleaven (2015).

The contraction derives directly from the use by software marketers of the term 'FinTech' to refer to technologies applied within the financial services sector, particularly those that are perceived to be disruptive or potentially profitable. The motivation for projection of the term RegTech was the desire for "regulatory reporting and analytics infrastructure ... typically to improve efficiency and transparency [in financial regulation]" (UKGOS 2015, pp.12, 47).

The RegTech notion was very quickly co-opted by the financial services industry association, the Institute of International Finance, without attribution (IIF 2015). IIF adopted a narrow definition of "the use of new technologies to solve regulatory and compliance requirements [in the financial services sector] more effectively and efficiently" (IIF 2016, p.2). A slightly different but also narrow approach was adopted by the UK Financial Conduct Authority: "RegTech is a sub-set of FinTech that focuses on technologies that may facilitate the delivery of regulatory requirements more efficiently and effectively than existing capabilities" (FCA 2016, p.3). Academic papers on the topic have generally adopted such definitions as their starting-point (e.g. Arner et al. 2015, Daly & Butler 2018, Anagnostopoulos 2018, Currie et al. 2018). In Butler & O'Brien (2019), it was reported that the UK's financial regulators had developed a proof-of-concept tool for 'Digital Regulatory Reporting', expressing laws and policies in machine-processable form.

It is only natural for the idea to loom large for financial services corporations. This is because of the imposts arising from regulatory measures to safeguard against the economic and social costs arising from the spectacular failure of softer regulatory forms, resulting in financial crises (RBA 2014). In addition, the industry has borne the brunt of frequently-changing interventions by legislatures and law enforcement agencies under the pretence that organised crime, the drug trade, human trafficking, terrorism and child pornography will all be magically defeated provided that the public accepts that every financial transaction must be identified and monitored (Zagaris 2004, Gilmore 2004).

RegTech providers naturally 'follow the money' and focus on large corporations that have substantial obligations imposed on them by formal regulatory instruments, and hence need to perform onerous compliance activities. The financial services industry will inevitably remain an important focus. RegTech's potential scope is, however, far wider than that. Other industry sectors are subject to formalised

regulatory requirements, and many looser and less stringent business processes can also benefit from technological support.

Regulatory arrangements are important wherever natural controls fail to curb excesses. This paper contends that, particularly in view of the scale of contemporary economies and societies, technologies need to be harnessed in support of activities of all participants in regulatory processes. This paper conceptualises the central concept in this paper as follows:

> ***RegTech*** *means technological applications in support of the activities of regulators, of regulatees, and/or of entities that are intended to be beneficiaries of regulatory activities*

This paper works on the assumption that regulation is an applications area for IT in just the same way as are Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), eHealth and Geographical Information Systems (GIS). As with any such applications area, both professionals and researchers require some degree of technical expertise in the area in order to make well-informed and meaningful contributions. The following section briefly identifies relevant literature. That is then built upon by presenting a framework for the development of research projects and programs in the area.

3 The Emergent RegTech Literature

The previous section noted the first uses of the term 'RegTech' in 2015. A series of searches was conducted in order to detect the rate and nature of development of a literature on the topic, commencing with the source that draws on the largest catchment area, and moving on to collections with a narrower focus. A detailed explanation of the search techniques that were applied is in the Annex to this article. This section provides an outline of the searches, and a summary of the findings.

The first round of searches had their focus on the term 'RegTech'. Despite the steady growth in hits on Google Scholar, very few mentions were evident in the Basket of 8 journals and the AIS eLibrary, and none at all in Bled Proceedings 2001-19. The second round searched in the same venues for variants of the term 'regulation'. This identified considerably more papers, although considerable numbers were of limited relevance to the purposes of the study. The end result was 40 journal articles, of which 24 are in Basket of 8 journals, and 36 papers in IS-cognate conferences.

A few systematic literature reviews exist (Cleven & Winter 2009, Akhigbe et al. 2015, Hashmi et al. 2018). A number of research agendas have been presented (Coglianese 2004, Abdullah et al. 2010, Cousins & Varshney 2014, Akhigbe et al. 2017). Few of the works are highly-cited, however. The largest Google citation-counts that were identified were between 70 and 80 for Coglianese (2004) and Abdullah et al. (2010), and about 40 for Duncombe & Heeks (2003).

Most of the published research has been specifically from the perspective of regulatees, with the primary focus on compliance, and the limitation of damage to regulatees' interests. Some papers are concerned with operational aspects of IS, in particular the influence of regulatory measures on IT applications and their use (Mlcakova & Whitley 2004). Others study regulatory regimes' impacts on system design (El Kharbili 2012, Knackstedt et al. 2014), on business process management (Schultz 2013, Fellman & Zasada 2014, Sadiq & Governatori 2015), and on shared infrastructure (Reimers et al. 2015). Difficulties in achieving compliance were considered in Smith et al. (2010) and Gozman & Currie (2014), while Clemons & Madhani (2010) considered circumstances in which new business models overwhelm existing regulatory mechanisms.

Regulation's strategic impacts were recognised even during the early years of strategic IS research, although a great deal of the literature regards regulation almost exclusively as a constraint rather than as an opportunity, with regulation referred to as a 'hurdle', 'barrier' or 'issue' confronting business. On the other hand, impacts of regulatory regimes on strategic IS can be not only significant, but also positive or enabling (Knackstedt et al. 2013). One example is where regulatory measures provide comfort to the individuals and organisations that buy products and use services. Further, to the extent that regulators take enforcement actions against

corporations that fail to fulfil their compliance obligations, the negative impacts of maverick competitors can be reduced, and the positive images associated with mainstream providers can be enhanced. In addition, regulatory measures can create or strengthen barriers to entry by competitors (Klapper et al. 2006, Lane & Koronios 2001), and can increase barriers to exit by customers. Moreover, in some sectors, regulatory arrangements can strongly influence and even dictate industry structures and processes (Rukanova et al. 2009, Watson et al. 2010, Rai et al. 2015).

This study is less concerned with the mainstream of compliance by organisations with regulatory requirements to which they are subject, and instead has its primary focus on the interests of organisations that perform regulatory functions, and of the intended beneficiaries of the regulatory measures, most commonly consumers and small business. The literature search identified a modest number of papers that have the design of regulatory measures as the central focus (Neo 1992, Clarke & Jenkins 1993, Williams 1994, 1996, Hosein & Whitley 2002, Knackstedt et al. 2013), while some acknowledge that regulators have a perspective different from those of regulatees (e.g. Gomber et al. 2018).

The search in the accumulated Bled corpus identified 11 papers that were relevant to this focus. Of those, 6 examined public policy issues, and from the perspective of the the public interest rather than that of corporations. The issues arose in the contexts of spectrum management (Delaere & Ballon 2007), pharmaceutical pedigree (Higgins et al. 2009), financial market surveillance (Alic et al. 2013, Alic 2015), drug counterfeiting (Kipp & Schellhammer 2019) and taxi services (Heikkila & Heikkila 2019). A further 5 papers considered a range of regulatory mechanisms (Polanski 2005, 2006, Clarke 2006, Burgemeestre et al. 2010, Smit et al. 2016).
Key conclusions from the survey of the literature are that the IS discipline has paid only limited attention to regulation, that the large majority of such studies have been compliance-oriented, but that some research is conducted with regulators and beneficiaries in mind.

The author contends that considerably more opportunities are available to IS practice and IS research, provided that a sufficient framework is established to enable those opportunities to be addressed. IS professionals can make practical contributions to the quality of regulatory regimes, as well as to the application of

information technologies in support of compliance with those regimes. There are of course also many implications for IS research.

4 A Framework for RegTech Research

In previous work, the author has reported on the development and exposition of a framework whereby IS professionals and academics can properly understand regulatory regimes, can identify opportunities for the development and deployment of RegTech, and can conceive, design and deliver appropriate technological support to relevant organisations (Author 2018). This section provides a necessarily very brief rendition of that framework. The following sections then demonstrate its value as a means of considering how RegTech can be applied in a particular sector.

During the pre-theoretic phase in a new sub-field of IS, a research framework provides structure to themes and issues, including descriptions of fundamental concepts and processes (Wand & Weber 2002, Avgerou 2008, Newell & Marabelli 2015, Clarke 2019). The framework presented here comprises four models. The first model draws on the literature to articulate the **Nature and Purposes** of a regulatory regime. The model defines the function that regulation performs, identifies the central players – distinguishing regulators, regulatees and beneficiaries, and describes the relationships among them, the processes whereby regulation is achieved, and the criteria whereby the appropriateness or otherwise of a regulatory regime can be evaluated

The second model partitions the space, by distinguishing the **Layers** within which regulatory measures are commonly conceived (Ayres & Braithwaite 1992, Drahos 2017, Drahos & Krygier 2017). The highest levels of Figure 1 depict the formal alternatives, and beneath that are shown the self-governance alternatives, and two forms of systemic governance.

Of particular significance for the analysis presented here, the second-lowest Layer is 'infrastructural regulation'. Regulatory functions can be performed by physical artefacts, such as the mechanical steam governor. IT' can be harnessed to the same purpose. A highly-cited expression of this is 'West Coast Code' (Lessig 1999, Hosein et al. 2003). This involves features of the infrastructure supporting or reinforcing positive aspects of the relevant socio-economic system, and precluding or inhibiting

negative aspects. Those features may be byproducts of the artefact's design, or they may be retro-fitted onto it, or architected into it. A simple example is the prevention of a transaction being conducted until particular data has been entered and authenticated.

The framework overviewed in this section is intended to support the analysis of individual industry sectors and segments. The following section outlines a category of industry sectors that have been attracting considerable attention, and that represent an appropriate basis for testing the framework's suitability for its intended purpose.

The third model articulates the categories of **Players** that act within the regulatory space. The fourth model, **Play**, examines the dynamics within that space, as each of those actors seeks to satisfy its own interests.

Figure 1: A Hierarchy of Regulatory Mechanisms

Figure 2 builds on the basic set of regulators, regulatees and beneficiaries, and embodies a sufficiently deep model to support analysis of complex real-world environments.

The third model articulates the categories of **Players** that act within the regulatory space. The fourth model, **Play**, examines the dynamics within that space, as each of those actors seeks to satisfy its own interests. Figure 2 builds on the basic set of regulators, regulatees and beneficiaries, and embodies a sufficiently deep model to support analysis of complex real-world environments.

The combined understanding of the regulatory space, layers, players and plays enables not only policy-makers, but also IS executives, practitioners and academics, to perform the 'sense-making' activities that necessarily precede the conception, design, development and deployment of new IS, and the adaptation of existing IS. The framework also provides the foundations for description, interpretation and critical analysis of the comprehensiveness, effectiveness and efficiency of a design, and assessment of its likely impact.

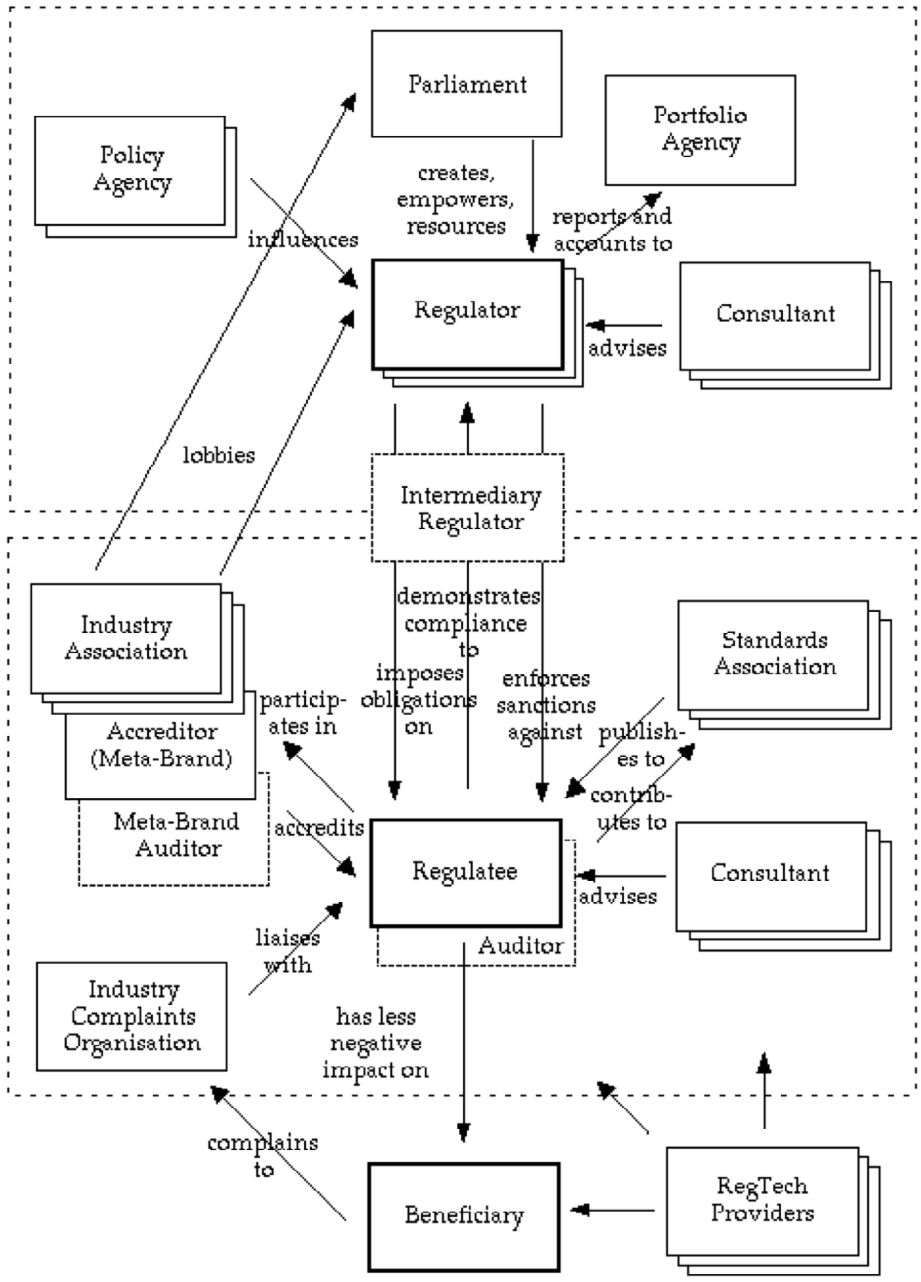

Figure 2: Players in Regulatory Schemes

The framework overviewed in this section is intended to support the analysis of individual industry sectors and segments. The following section outlines a category of industry sectors that have been attracting considerable attention, and that represent an appropriate basis for testing the framework's suitability for its intended purpose.

5 The Platform-Based Business Sector

A definition of platform-based digital marketplaces was provided in the Introduction to this paper, based on Taeuscher & Kaudion (2018). A regulatory agency recently offered a simplified description of digital platforms as "applications that serve multiple groups of users at once, providing value to each group based on the presence of other users" (ACCC 2019, p.41). Platform-based corporations consolidate suppliers into a managed collective, and provide them with means of being matched with customers. Exemplars of such sharing or crowdsourcing platforms that have attracted particular attention in recent years include eBay (since 1995), booking.com (1996), Expedia (1996), Tripadvisor (2000), Mechanical Turk (2005), YouTube (2005), Airbnb (2008), Freelancer.com (2009), Pinterest (2009) and Uber (2009). Claims are made by and for such platforms that they provide information infrastructure to enable more efficient matching of supplier capabilities with customer needs and more efficient use of assets and labour to deliver services.

The emergence and proliferation of the platform model has excited a great deal of enthusiasm in the formal and informal business media (Kavadias et al. 2016, Smith 2016, Uenlue 2017a, Kumara et al. 2018, Teece 2018). Common themes are inefficiencies arising from longstanding regulatory arrangements, and the benefits of de-regulation (Cannon & Summers 2014, Geradin 2015, Wallsten 2015, Kaplan & Nadler 2015). A sub-set of the conversation is concerned with the adaptation of regulatory schemes. In some jurisdictions, regulatory schemes have collapsed and negative impacts of unregulated markets have been felt, resulting in a focus on re-regulation (Ballon & Van Heesvelde 2011, Rauch & Schleicher 2015, Wyman 2017, Heikkilä & Heikkilä 2019).

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New platforms typically launch by harnessing new entrants, e.g. consumers with used assets to sell (e.g. eBay), home-owners with spare space that in the past has not been systematically let out for use by other people (Airbnb), and car-owners who have not previously offered fee-for-service car-rides (Uber). Many such schemes have taken advantage of loopholes in existing regulatory schemes to under-cut the prices in existing, regulated markets and thereby gain a meaningful market-share. This can achieve the ratchetting down of the regulatory regime, and may also enable the recruitment of existing suppliers into the scheme. In time, a re-concentration of market power may occur, accruing to the platform-based company, and this may in turn enable price-increases. Stock market valuations suggest a belief among investors that operations that initially make very large losses are likely to later achieve super-profits from the monopoly power that they develop.

Alternatively, a parliament or a regulator may assert its authority. This is likely to force the disruptor to comply with the law and significantly adapt its business model, thereby reducing its cost-advantage. It may even preclude the corporation from operating in that jurisdiction unless it establishes a local subsidiary that adopts a materially different business model.

Responses by regulators in some sectors have been very slow and piecemeal, whereas others have moved more decisively. An Australian regulatory policy agency has recently examined digital content platforms, in particular Google Search, Facebook, YouTube and Instagram, with a focus on their impacts on news reporting and journalism (ACCC 2019). It found that the fundamentally different approach taken by digital content platforms is enabling them to avoid a range of existing regulatory

measures, and that this has created serious threats to transparency, to competitive markets in digital content and in advertising, to the economic viability of news reporting, and to consumers' interests. Its Report recommended many adaptations to the regulatory regime for digital content.

The following section draws on and applies the concepts and insights provided by the framework for RegTech research outlined earlier, in order to identify contributions that can be made by technology, and by the IS profession and discipline, to the regulatory processes involved in the platform-based business sector.

6 RegTech Opportunities in the Platform-Based Business Sector

The Framework for RegTech Research introduced earlier was originally articulated to enable the analysis of sectors that have established a degree of maturity and stability. However, it can also assist in analysing circumstances in which disruption is occurring. It provides a basis for mapping the existing regulatory context that the disruptor is challenging. It can assist in reviews of the hierarchy of regulatory mechanisms, with a view to strengthening enforcement of existing requirements, or to easing the regulatory burden while still achieving the purposes for which what are now seen as unduly onerous requirements were imposed. Further, it can assist in identifying areas of particular inefficiency or disadvantage, which may represent an opportunity for de-regulation or rationalisation.

This section applies the Framework to the new platform-based entrants disrupting existing industry sectors, as outlined in the previous section. It commences by considering platforms in the abstract, then examines the regulatory implications of Uber's operations.

6.1 Generic RegTech Opportunities

Many of the generic measures identified in the Annexes to Author (2018) have application to the platform-based approach. In all of the upper five layers of Figure 1, system features need to support **formal and self-regulatory mechanisms**. When incidents are reported, and complaints are made, management systems are needed, to ensure that each case is logged, tracked and managed, and the findings are used

to stimulate action. Statistical reporting, on operations generally, on exceptions, on incidents and on complaints, needs to go beyond support for operational management to enable the organisation to achieve compliance, demonstrate to regulators that it has been achieved, and hence avoid the additional costs of unnecessary interruptions to the business management focus of managers and executives.

Regulators of platform-operators need case management systems for own-motion investigations and the handling of individual complaints. Some need information systems to manage registration or licensing. RegTech can also serve needs of beneficiaries of regulation, although in many cases an intermediary, representative or advocacy organisation may need to act as a proxy for their interests. Laws, policies, codes and undertakings need to be accessible and searchable. Guidance is needed in relation to particular patterns of corporate behaviour and the extent to which they are and are not reasonable, and are and are not compliant with laws, policies, codes and undertakings. Complaint preparation needs to be supported by guidance notes, templates and/or document-generators. Individual complaints, but particularly representative complaints on behalf of all or a class of individuals, need support, e.g. correspondence generation and filing, and reminders of deadlines for responses.

Infrastructural regulation has attracted remarkably little attention in many industry sectors and segments. Many regulatory schemes are of long standing, and their design reflects much less sophisticated computing, data management and data communication technologies than are now available. Yet researchers appear to have overlooked the scope for IT to make greater contributions. For example, published research agendas for digital platforms (e.g. de Reuver et al. 2018, Constantinides 2018) make only limited mention of regulation, and almost none of infrastructural regulation. Even a book concerned with public values overlooks the possibility (van Dijck et al. 2018).

An important exception is Boudreau & Hagiu (2009). The focus of those authors is on the platform-operator regulating its contributors and users for the good of itself, not with the regulation of the market segment as a whole for the benefit of external beneficiaries. However, there are likely to be ways in which the self-interest of the

platform-operator coincides with the interests of other parties, giving rise to at least some incidental public benefits.

The Annexes to Author (2018) catalogue generic infrastructural measures that have application to the platform-based approach. Regulatees need data and process integrity controls, access controls, audit trailing, and automated monitoring of audit trails, all embedded within their operational systems. Platform-operators also require exception-detection mechanisms embedded within their systems, to provide themselves with the opportunity to address individual problems and systemic issues, and to do so before they give rise to harm to regulatory beneficiaries and come to the attention of regulators. Automation of statistical reporting to the corporation's executives ensures forewarning of compliance issues that need addressing, such that anticipatory action can be taken in advance of queries from regulators.

Regulators, meanwhile, can be most effectively supported by automated statistical reporting directly from regulatees' systems, and auto-notification of exceptional individual cases. Direct access to databases in regulatees' systems exists in some financial services contexts. Operational features can be embedded in regulatees' systems that are for the benefit of the regulator rather than the regulatee, such as the prevention of transactions where mandatory conditions are not fulfilled. Examples arise particularly in the context of share trading platforms. Scope also exists for infrastructural features for regulatory beneficiaries, such as auto-reporting to individuals when access to their personal data occurs. This approach is already common when individuals' passwords are changed, or an access occurs from a new IP-address, but it has also seen application in some healthcare contexts.

6.2 A Test-Case: The Uber Platform

The particular platform that has attracted most attention, by consultants and academics alike, is the Uber 'ride-sharing' platform, which has had major impacts in many economies. In addition to its own significance, Uber has stimulated a range of look-alike disruptors in ride-services markets. Many of these are additional or alternative new entrants in the market for taxi-fares, or a substitute for taxis (e.g. Lyft, Bolt, Didi, Ola). In some cases, however, they have instead displaced use of public transport, bicycle-riding and walking. Other Uber-like start-ups have been in

the motor-cycle and motor-vehicle courier markets (e.g. Foodora, Sherpa, Zoom2U), and in the heavy goods vehicle arena (e.g. Flexport, Convoy, Saloodo).

On the supply side of the Uber platform, drivers are attracted by ready access to work, no need to have any knowledge of local geography, flexible hours, the ease and speed of joining up, and the limited need for business management. On the demand side, Uber's value proposition comprises easier ordering, shorter delay before pickup, cheaper trips, and no-effort payment. For a comprehensive review of Uber's business model, see Uenlue (2018).

Perceptions of Uber's impact vary, because of enormous differences in contexts across the company's areas of operation (Carson 2018). In the author's regional city, for example, taxis continue to dominate weekdays, but are challenged by Uber in the evenings and on weekends. This appears to be in part 'cherry-picking' behaviour, servicing only the periods offering lower idle-time factors and higher prices (termed 'surge' by Uber). In the process, this adds capacity when it is most needed. Anecdotally, another key factor is that most Uber drivers in the city in question use it only as a second income, and have a full-time weekday job. One study suggests that whereas large cities may have seen Uber and its imitators take as much as half of what was previously the taxi-market, the market-share achieved in smaller cities and large towns appears to be far lower, and the impact in regional and rural areas very limited (IPART 2019).

Uber is a particularly appropriate choice as a case study on RegTech opportunities, because its culture generally is somewhat extreme (Jordan 2017), and prominent within that culture is its **wilful disregard for existing regulatory regimes**. The range of regulatory non-compliance Uber has been accused of is very wide (Henley 2017, DWO 2018). More than half of the issues arise from the nature of the business. A major category is operation without the necessary business licences and not meeting the standards to qualify for one - such as driver qualifications and local knowledge, worker protections and a sufficiently broad area of service. In some jurisdictions, Uber has been associated with an elevated incidence of driver offences such as indecent assault. Another cluster involves breaches of competition law (price-fixing, collusion, misleading practices), and of tax law. Breaches of labour laws have also been common (wrongfully denying employee entitlements and rights, using the pretence that they are independent contractors). Many platform-based

corporations have ushered back in the much-maligned 'piecework' mode of remuneration for labour, with substantial reductions in workers' income camouflaged by the enthusiastic use of terms such as 'gig economy' and 'crowdsourcing' (Kaine et al. 2017, Akhtar 2019).

Even where acting entirely legally, Uber and other ride-sharing platforms can have material impacts that require **adaptation by regulators**. For example, there is evidence that Uber is exacerbating traffic congestion in many cities, leading to adjustments to congestion fee regulations in order to achieve a reduction in traffic and recover displaced use of public transport (Bond 2019, Giordano 2019). In Heikkilä & Heikkilä (2019), the scope is investigated for applying the commons governance principles of Ostrom (1990).

The model of **regulatory players** in Figure 2 is readily applicable to the specifics of Uber. As the diagram indicates, multiple regulatory schemes and policy agencies are relevant. A particular challenge that arises from Uber's operation in multiple countries is the diversity of approach, structure and processes among Regulators. In the most comprehensive analysis seen to date of the regulatory aspects of the Uber-driven taxi market, Wyman (2017) identified the "pillars of taxi regulation" as entry, fares, consumer safety, worker protections and universal service requirements (pp.31-74). In some analyses, the Beneficiaries are customers, while in others they are Uber's drivers, and on occasions the jurisdiction's revenue-collection function is in focus. A category of Consultants of particular relevance in Uber's case is what Uenlen refers to as 'lobbyists', whose role is to hold off regulatory enforcement.

Several further insights arise that suggest refinements to the current players model. A key issue in the Uber context is that **drivers are regulatees** (in relation to their competencies, their responsibility for their vehicle, and their behaviour in relation to customers), **but also beneficiaries of regulation** (in relation to their working conditions and remuneration). This highlights the need for the model to depict 'Beneficiary' as a plural rather than a singular entity, so as to encompass both passengers and drivers. There is also a need to support different **segments within heterogeneous populations**, differentiating, for example, business customers from consumers, controlled markets such as for school transport, and urban, suburban, regional and remote locations (Heikkilä & Heikkilä 2019). An important segment is customers in wheel-chairs, who may be impacted quite differently from ambulant

ride-seekers. Similarly, on the supply side, drivers fully-dependent on ride-sharing for their livelihood have somewhat different interests from part-time, second-income drivers.

Another challenge is the need for some **'Business Partners'** to be factored into analyses. Of particular importance are technology providers that deliver custom-built or customised tools for collecting and managing data, matching demand and supply, providing convenience and ease-of-use, and satisfying customers' and drivers' hedonic needs. Motor vehicle providers may also become significant, to the extent that they deliver, or trial, Uber-favouring features such as embedded vehicle-tracking, automated navigation, and driverless operation. Uber's partners may of course intersect with the 'RegTech Providers' that are already included in the model – resulting variously in cross-leveraging and compromise.

The framework, particularly if subjected to some modest adaptations, therefore provides a strong basis for describing the concepts and processes underlying platform-based business sectors. How well does it deliver against its second purpose, the identification of opportunities for the development and deployment of RegTech in a specific context such as Uber and similar ride-sharing services?

The previous section identified a range of generic opportunities. Most of those ideas are applicable to the specific case of Uber, but both qualifications and adaptations are necessary. At the formal regulatory and self-regulatory levels, statistical reporting and analysis loom large for Uber. It generates a vast treasure-trove of data, not only from the high volume of transactions, but also from its embedded and extensive tracking of both drivers and customers. Apart from supporting strategic decision-making, the analysis of this data supports Uber's ongoing battles with regulators. In part, this battle is engaged indirectly, by addressing the media, the public, policy agencies and parliamentarians. The company's focus is less on compliance and more on demonstrating that the game has changed, that it has changed for the better, and that (preferably) selective de-regulation or (at worst) re-regulation is needed. This can be achieved through anecdotes, supported by data, that convey the image of the platform business model delivering public value.

A key example of this is supply-side elasticity during peak demand periods. The conservatism long evident in most jurisdictions has resulted in no more taxis being available during high-demand periods than at other times, e.g. few jurisdictions issue peak-hour-only taxi-permits. This is reinforced by the rusted-on norm of a fixed tariff – in many cases with higher overnight rates, which is the inverse of the rationalist economic recommendation to use upward price-flexibility to stimulate supply. (Even conservative government public transport services use time-of-day-dependent tariffs in order to shift some of the demand to off-peak periods). Uber's data on ride-availability during 'surge pricing' periods is capable of demonstrating the efficacy of price-flexibility in varying supply and thereby satisfying customer needs. This goes well beyond predictable morning and evening CBD demand, to include sporting and entertainment event peaks and (perhaps less convincingly) wet weather peaks.

Given the central role that IT plays in the Uber platform, there is a heavy emphasis on infrastructural regulation. For Uber to continue to hold regulators at bay, ongoing public goodwill is vital, and hence the media needs to carry feel-good stories, to not discover newsworthy bad news, and most of all to not have the opportunity to snowball bad news stories. This depends on early problem identification, and early action to pre-empt negative reports. That in turns requires automated exception and incident reporting, and an incident management system that nags those responsible for managing issues, all deeply embedded in the corporation's operational systems.

Regulatory purposes can also be served. In order to bolster the argument that existing regulatory regimes are appropriate, quality reporting processes are needed on service-quality, driver-performance and safety-incident reports, supported by apps in the same way that ride-requesting is supported - and even by the same apps. The resulting data can be funnelled through services not controlled by the platform, such that Uber cannot massage the results. Similarly, direct transaction-feeds to regulators can be built into such systems to enable monitoring of key factors such as resource-utilisation, load-patterns, pollution-generation, and revenue-flows to individual drivers.

There is limited evidence of such discussions in the literature, although Wyman (2017) gives consideration to the contributions that could be made by RegTech: "Technology might be harnessed to address concerns that formally removing the existing legal limits on the number of street-hailed taxis might lead to oversupply in certain geographic areas. ... [V]ariable congestion charges might be used ..., and the app provider might be charged with collecting the congestion charge on behalf of the governmental authority" (p.39).

Similar approaches can be applied to the many other instances of platform-based markets. However, the opportunities may not always be apparent to regulators. For example, in the Short-term Holiday Letting (STHL) market segment, driven by the Airbnb model (Uenlue 2017b), a review of options for reconsidering the role of regulation (NSW 2017) was limited to formal laws and self-regulation, and completely overlooked the possibility of using information technology as a tool within the mix.

This case study provides evidence in support of the contentions that RegTech creates many opportunities for IS practitioners and researchers, and that the Framework for RegTech Research outlined in this paper enables their discovery and supports their articulation.

7 Conclusions

This paper has outlined a Framework for RegTech Research. It has also considered the usefulness of that Framework in understanding regulatory layers, players and play, and in identifying opportunities for applications of IT to regulatory matters. The particular context on which the Framework's usefulness was demonstrated is the currently very topical field of platform-based businesses.

An examination of the existing literature concluded that, to the limited extent that regulatory applications and RegTech have been addressed, the interests of regulatees dominate research discussions and research design. A great deal of the literature is concerned with organisations achieving compliance as efficiently as practicable (where the regulator is strong) or achieving the appearance of compliance (where it

is not). Even in this mainstream area, the Framework assists in unearthing additional research opportunities.

Although this study generated many suggestions in relation to compliance by corporations with regulatory requirements, the paper's most significant contributions lie elsewhere. Consistently with the conference theme of 'Enabling Technology for a Sustainable Society', the main focus has been on IT applications and features that support regulators, or serve the interests of the intended beneficiaries of regulation – most commonly individuals and small business, but in some contexts the physical environment.

The interests of regulators and of the beneficiaries of regulation are currently not well served by research. The Framework creates the scope for a great many projects and programs that contribute to the greater good rather than just to the interests of particular corporations. Opportunities exist for IS theorists and professionals to study aspects of the platform approach beyond business models, extending to strategic impact, and to public policy. Researchers can make contributions to rational debate in disrupted markets. Professionals can design and prototype IS and IS features that implement or support desired safeguards and controls, and that do so not only effectively, but also efficiently, flexibly and adaptively.

Annex

Details of the Literature Search:
http://rogerclarke.com/EC/Bled-RTFB-Annex.pdf

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RURAL AREAS ON THEIR WAY TO A SMART VILLAGE - EXPERIENCES FROM LIVING LABS IN BAVARIA

LISA-MARIE HANNINGER[1], JESSICA LAXA[1] & DIANE AHRENS[1]

[1] Deggendorf Institute of Technology, Technology Campus Grafenau, Grafenau, Germany, e-mail: lisa-marie.hanninger@th-deg.de, jessica.laxa@th-deg.de, diane.ahrens@th-deg.de.

Abstract This paper presents an overview of the approaches and experiences from existing living labs: german rural villages in which several digital solutions had been developed and implemented. The test villages have been selected based on a competition and are funded by the Bavarian state government in the project "Digitales Dorf" (Engl. digital village). Started in 2016 several measures had been taken to push digitalization in these rural areas with the goal to create equivalent living conditions to urban areas. The research question is how digitalization enhances the value of rural areas and which methods can be used to overcome the digitalization gap with a transferable and simple approach. This paper focuses on the transformation process rather than digital solutions, and presents requirements and best practices to promote digitalization in rural environments, their municipal processes and traditional approaches in everyday life.

Keywords: rural development, digitalization, digital transformation, bottom-up, citizens' dialogue.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.7
ISBN 978-961-286-362-3

1 Introduction: the need of pushing smart rural areas

A country's society does not digitalize on its own, and certainly not equally among different geographical structures. According to an annual study on the digital society in Germany conducted by the Initiative D21, around 15% of the population still does not use the internet (Allianz pro Schiene e.V., 2019). Further, regional diversities become clear: metropolitans (500,000 inhabitants and more) use digital applications more frequently and competently than the rural population (up to 20,000 citizens in a municipality) and are more open to technological change. (Initiative D21 e.V., 2019) This attitude is not necessarily inherent, but can be attributed to different structural conditions: Despite well-intended governmental support for broadband expansion (Bundesministerium für Verkehr und digitale Infrastruktur, 2019), rural areas are at a disadvantage, which is reflected in lower transmission speeds and poorer mobile phone coverage, particularly in border regions (Bundesamt für Kartographie und Geodäsie, 2016). This makes it more difficult to implement digital innovations with higher transmission requirements, but must not lead to rural areas being disadvantaged and consequently left behind.

Despite trends such as urbanization and rural exodus, the following conditions illustrate the significance of rural areas for Germany with its 83.1 million inhabitants: (Statistisches Bundesamt, 2020) rural areas represent more than 90% of Germany's territory, but are the habitat for less than 60% of its citizens, which illustrates the increasing overload in big cities like Munich. Digitalization can play a significant role to stop rural exodus, if it is not used in urban areas only but if it also serves rural areas to meet the challenges there. Aside from "Smart Cities", society needs "Smart Villages", too.

This paper aims at sharing information gained from the living labs in the project "Digitales Dorf Bayern"[1] (digital village Bavaria). The objective of the research is to determine which digital solutions can be used to make living conditions in rural areas more attractive. In this context, the living labs are municipalities participating in the funding project, which offer space and use cases for field tests for digitalization measures in rural areas. For this purpose, an overview of digitalization and rural areas including their challenges builds the theoretical basis. This is followed by a short

[1] cf. Funded by Bavarian Ministry of Economic Affairs, Regional Development and Energy.

description of the pilot project "Digitales Dorf" and a view onto a successful and sustainable digitalization respective transformation process in rural areas. In addition, it is shown how demand-oriented digitalization in rural areas can work in practice and which benefits these "living labs" bring.

2 Methodical Approach

An intensive dialogue with citizens and the monitoring and support of the communities in the digital transformation are essential elements of the project realization in the pilot regions. Together with the citizens, practical digital everyday helpers are to be developed and tested. Dialogues with citizens and inventories of the initial situation in the communities are being carried out continuously across various topics. The evaluation aims to gain a general overview of the current use of digital offers and citizen services in the municipalities. The experience and requirements gathered will be taken into account for the development of a digitalization concept and will also be included in the solutions. Implemented measures are repeatedly re-evaluated. The experience gained in this project describes the process and can be used as a guideline for future digitalization projects. For the pilot regions this should result in a boost of the digital offerings in the communities.

3 Digitalization in rural areas

3.1 The term "rural area"

Even if a common, approved definition of rural areas in politics, science and society is still missing (Maier, 2008), various quantitative and qualitative criteria or characteristics apply (Magel, 2007). Rural areas define as village and small town structures with low building and population density. The townscape is shaped by agriculture and forestry as the economic sector. Rural areas are poorly accessible and tend to have inadequate infrastructure and supply facilities. In addition, rural areas suffer from low job density with resulting negative commuter balance. Citizens are more likely to have closer and more manageable interpersonal relationships. The rural landscape is characterized by natural and semi-natural elements.

Thresholds for the metric indicators that would clearly describe rural areas are missing. At least the criteria allow a categorization and thus a comparison. Initiative D21, on the other hand, uses the number of inhabitants below 20,000 in a municipality as the criterion for "land" (Initiative D21 e.V., 2019). This applies to 96% of municipalities in Bavaria. (Deutscher Städtetag, 2019) Also in practice, it proves difficult to define "the one" rural area. Instead, there are many different types of rural areas with special potentials and challenges. (Wiechman & Terfrüchte, 2017)

3.2 The digital challenges faced by rural areas in Bavaria

The terms digitization and digitalization are often mixed up in their meaning. Digitization is the transformation of an analog process into the digital form of zeros and ones (Gartner, 2020a), and therefore a subtopic of digitalization. The latter is well described in Gartner's glossary:

> "Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business." (Gartner, 2020b)

Despite the fact that rural areas have many benefits such as a high sense of belonging, a healthy environment and lower rent or land costs (Maier, 2008), it still suffers from disadvantages: The lack of medical specialists (Bertelsmann Stiftung, 2015), accessible mobility (Allianz pro Schiene e.V., 2019) and modern equipment in schools (Deutscher Bundestag, 2018), for example, does not measure up to the offerings in the cities. Citizens therefore face long travel distances to everyday services, which come along with limited mobility offerings (Stentzel, U., Piegsa, J., Fredrich, D., Hoffmann, W., & van den Berg, N., 2016). The economic structural weakness leads to a high number of commuters leaving rural areas to get opportunities in job offerings in urban areas. (IHK Niederbayern, 2017) For the local companies in rural areas, this means that skilled labor potential is lost, which further aggravates the already tense situation. In the long term, this closes the circle of migration from the countryside into the cities and their agglomerations (rural exodus). In contrast to the modernized urban infrastructures, as well as better hard- and software conditions that already exist in the cities, a technological modernization of the systems in rural authorities and a change of mindset is largely necessary to support the adjustment from conventional processes to a digital everyday life. In

contrast to cities, digitalization is rarely present in the everyday life of citizens. The rural aging of society means that the proportion of citizens actively participating in digital life is low (Currie and Philip, 2019). The lack of urge to try out new things, partly due to the very traditional social structure, makes the introduction of new technologies considerably more difficult in rural areas than in cities. Statistics from the IW-Report 2019 (Burstedde & Werner, 2019) show that the proportion of academics in rural areas is very low, which suggests that, from a professional point of view, there is very little knowledge of modern technologies. The scope of challenges of digitalization often differs between rural, peripheral localities and urban areas. The term "digital divide" or "digital gap" refers to the fact that different access to information and communication technology causes kind of a gap between demographic regions. (Steele, 2019) However, one should treat this term and corresponding statement with caution: Not all rural communities likewise need the same fundamental preparation in digitalization. The term "gap" should also not suggest that city residents are all digital experts in contrast to the rural dwellers. Namely, digitalization and its usage are more distributed in cities because of better conditions like network access and (public) infrastructure. (Bundesamt für Kartographie und Geodäsie, 2016) Nevertheless, there are also city residents that have no or few touchpoints with digitalization, and there are simultaneously rural citizens, which are more technology-oriented.

4 The project "Digitales Dorf Bayern"

4.1 Overview: context and aim of the project "Digitales Dorf Bayern"

Under the leadership of the Bavarian State Ministry of Economic Affairs, Regional Development and Energy (StMWi), the project "Digitales Dorf Bayern" deals with the consistent mastering of given problems with the help of modern communication and information technologies as the key to sustainable rural areas and social life. The aim of the "Digitales Dorf Bayern" project is therefore to work together with local citizens to find adequate solutions for even better living together in the community, with transferability to other municipalities with little effort and without in-depth expertise. (StMWi, 2019) The project takes - under consideration of comparable initiatives - the digital potentials and developments of the last years as an opportunity to test new technologies and, if necessary, to use and evaluate already existing solutions in the communities, if available. Selected scientific institutions support the

pilot areas. The Deggendorf Institute of Technology (DIT) is responsible for three pilot villages respective regions in Southern Bavaria. If one considers the specific context in this work, digitalization has to be understood as kind of a digital revolution caused by the implementation and increasing use of the internet, digital technologies and devices in public life, business and private everyday life. The digital revolution has therefore different dimensions: a social, a political, an economical, a technical and an ethical. For the project "Digitales Dorf Bayern" the focus is on the social one, since research concentrates on the interaction between digital technologies and citizens respective their participation. In the presented paper, digitalization in rural areas is therefore specified as follows:

> Digitalization is the use of digital technologies to improve municipal services of general interest and social interaction. It affects primarily the social dimension in the process of implementing and using digital technologies and services, and learning how to deal with it. Its aim is to improve social interaction and everyday life for citizens in challenging rural areas. Indeed, rural areas cannot be compared to each other since they suffer from different structural problems and they all have a different initial situation regarding their digitalization knowledge.

This derived definition aims to help understanding the actual hurdles in rural areas in order to be able to use digital measures in a more tailored and targeted way. A special requirement is the transferability from one municipality to another. The definition has emerged from the general conditions of the living labs. It has turned out that it can be used as a guiding principle in all communities participating in the project so far. The difference to the approaches in smart cities is particularly clear, as digital solutions in urban areas are mostly alike due to structural similarities.

4.2 The two keystones of the living labs

Two aspects illustrate the successful approach in the project "Digitales Dorf Bayern": the holistic approach and the living lab-approach. Holistic in this context means finding digital solutions for all areas or spheres of life. This is important because real and sustainable benefit for the citizens is only created if the developed solutions are connected in order to provide a fully comprehensive service. Therefore, during setup of the project by government, the decision was pending which topics in everyday life should be considered. Being aware of the fact regarding

the generated added value through linking the spheres of life, various fields of action were examined for potential to catch up and for digitalization options to achieve improvements for citizens in rural areas. Figure 1 shows the selected spheres of life in the project "Digitales Dorf Bayern", all digitalization activities in the pilot villages and their state of development. Digitalization alone cannot solve all problems: Analogue togetherness is still essential for a healthy, functioning society. Further, all developed solutions are already today easily and digitally accessible with one account for the citizens via the so-called *Dahoam 4.0*® platform, distributed as a web-application and several mobile apps. The project strives to develop solutions according to the citizens' needs. This is done through the bottom-up approach, in which concepts are developed and mutually created in direct dialogue with the citizens. This is important, because many digital innovations suffer from a significant problem, if they are oriented exclusively to the technical possibilities. The following section emphasizes the living lab-approach when explaining the project's roadmap.

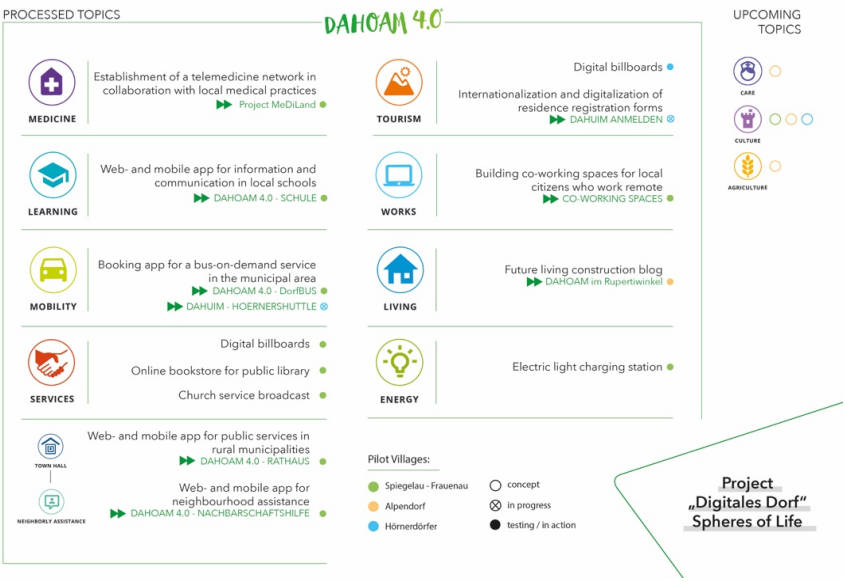

Figure 1: Defined topics aka spheres of life in the living labs
source: own illustration

4.3 Approaches of the living lab "Digitales Dorf Bayern"

In the following, the process steps for developing and implementing digitalization measures presented in Figure 2 will be described on the basis of the experiences from the three pilot villages. Positive evaluated methods are equally reflected.
One should distinguish between two roadmaps, the "macroeconomic" one, which aims to transfer the living lab tests and results, and the "microeconomic" one, how the projects are successfully and sustainably implemented within a pilot village.

Figure 2: Digitalization process in the living lab "Digitales Dorf Bayern"
source: own illustration

Step 1: Involve Stakeholders

All pilot villages provide a so-called core team, which works together for the entire duration of the project and is formed by three stakeholders. These are made up by the mayor of the municipality, the scientific advisors and the caretaker on the spot. The mayor of the municipality supervises and takes care of the final decisions throughout the duration of the project. The monitoring function by the scientific advisors, in this case the Deggendorf Institute of Technology, proves to be an advantage for the project regarding the guarantee of professional input concerning digital innovations, advice and overall help with hard- and software implementation. Additionally, the caretaker on the spot represents the interface between the local citizens and the scientific team. He or she is familiar with the pilot village, can coordinate on site at short notice and supports the core team with organizational skills.

Step 2: Information, sensitization and enabling

To raise awareness to the project and to generate motivation it is important to have an official "kick-off". These events attract public attention and illustrate the importance of the topic by the presence of political celebrities. An official kick-off shows the commitment to the project and the willingness to meet the challenges. After the kick-off, the working groups can be formed on basis of the previously defined fields of action. Their task is to identify the respective challenges in the region and to develop measures with the support of the scientific team. All citizen groups get the chance to be part of a working group and to inform them about suitable technological possibilities to create concepts with the other stakeholders. This requires again public relations work. This step needs several repetitions to raise citizens' awareness of the use of digital media by sensitizing them with implemented prototypes and services.

Step 3: Gathering of requirements

The project research shows, that measures should not base on technical possibilities, but rather on the region-specific challenges. Instead of high-flying, low-threshold solutions are required for the success of such projects: they can be implemented quickly, are visible to the citizens and associated with immediate benefits. In addition, this illustrates how the gathering of requirements should be addressed. If one starts from specific challenges and problems, solutions are created that offer real benefit. This is why the actively moderated bottom-up approach is so essential: it guarantees that the people who are most affected by the challenges are involved in the generation of ideas and therefore benefit directly from the solutions. This has positive impact on acceptance and usage of the solutions later on.

Step 4: Solution development with citizen involvement

All solutions in this project are developed according to the following criteria:

a) Use of already proven existing solutions over in-house programming
b) Building upon existing structures to avoid parallel or isolated applications
c) Easy-to-use for users: 1) Development by requirement, not by possibility 2) Design follows function

d) Low-cost transferability (regarding time and money) to other municipalities: The purpose of testing the measures in the pilot regions is not to implement specific solutions for unique problems. Ideally, it should be possible to transfer the solutions to many other rural areas with similar situations.

Step 5: Monitoring & evaluation

Monitoring and evaluation can assume different proportions. The usage of the digital solutions can easily be reviewed by analytics systems. However, if one wants to learn about detailed cost- and time-savings, more effort is necessary. Not only needs the developed solution itself monitoring and evaluation. The scientific team at DIT started to record steps and techniques of software development in order to make it easier to reproduce the creations when changes and further developments are required. This is also important in case of changes of employees or assuming responsibility by a third-part company. Learning from mistakes is one of the best options for further development and getting better. To gain from these benefits in a long term it is necessary to record also these issues as lessons learned.

4.4 Overview of the learning effects

The project periods described above turned out to be crucial to a long-term successful digitalization project. As trivial as it might sound, underestimating the significance of these easy steps might doom the project to failure. Undertaking a digitalization project that strongly influences the social and everyday life in rural areas needs to involve affected people. Interdisciplinary stakeholders with different backgrounds in sectors like informatics, socio-economics and local citizens prove to be valuable for a holistic project team. The caretaker on the spot turns out to be a key contributor to the projects' success. The ability to identify root problems in daily life of the locals and discussing them continuously simplifies the identification of requirements. The research shows that open to public participation platforms in form of working groups tend to pave the way to an open dialogue around the topic. To this point, created solutions within the living labs are tailored to the citizens' needs. It is important to keep the residents informed and updated about the developments to ensure that problems, misunderstandings or worries by the citizens are settled in an early stage. There will be always critical opinions of people who are

scared and / or avoid topics of digitalization. In addition, there is often a lack of awareness for improvements and modernization. Simple explanations can usually solve that. Technologies and solutions should be introduced and promoted by adequate communication channels according to target groups. This includes the usage of material in digital and - even if it seems obsolete in modern times - analogue form. If software solutions are not available on the market and have to be developed, particular attention should be paid to use systems that provide simple and barrier-free interfaces in order to produce a holistic application for the citizens: low-threshold solutions are required. In addition, the solutions should be easy to maintain and be able to operate without knowledge in software development for the municipalities. Still, established software or general technological solutions are in the need of care. It is recommended to appoint a responsible person in the community to deal with this issues, which is sometimes a problem in small municipalities due to limited staff.

5 Summary

This paper is about the research approaches in the project "Digitales Dorf Bayern" in order to determine which digital solutions can be used to make living conditions in rural areas more attractive. The results of the research project highlight the fact that digitalization is not only about technical novelties, such as robotics and artificial intelligence, but in context of everyday life and conquering infrastructural challenges especially in rural areas, it is about the people: About citizens that are affected by specific challenges and, as a consequence, the resulting digitalization measures. Living lab results show that interaction with the citizens throughout the entire process is crucial to a successful implementation. Mayors are mostly not aware about the unconditional meaning of the citizens' dialogue and therefore appreciate the projects strategy. To generate ideas, one should ask for the challenges the watched area and its inhabitants are faced, not for their "digitalization wishes". It's very important to consider the individual digitalization level which differs among urban and rural areas, and inside these groups, too. Not only people are individual, but also rural areas in terms that they have all their special initial situation, challenges and needs. The government should support rural areas not only with workforce, but also with sufficient infrastructure (e.g. broadband rollout, mobile phone network) and funding not only to create the basic requirements for digitalization, but also to develop digitalization measures and then to maintain them. To gain real benefit for

citizens, the project members should strive for connecting them across various spheres of life and with analogue infrastructure.

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A Classification of Organizational Interventions to Enable Detachment from Work

Jana Mattern[1]

[1] University of Muenster, Department of Information Systems, Muenster, Germany, e-mail: jana.mattern@wiwi.uni-muenster.de

Abstract Negative effects of extensive connectivity to work through excessive use of technology have yielded discussions about the right to disconnect for employees. Organizations are beginning to introduce interventions that aim at enabling their employees to detach from work (i.e., refrain from work-related thoughts and activities during non-work hours). However, there is limited academic research on how organizations should introduce interventions that lead to a successful disconnection of their employees. Based on an interdisciplinary literature review and reports on companies' best practices, this study proposes a classification of organizational interventions based on the level, target, and mechanism of the intervention. I include the theory of psychological detachment to propose a measurement of the success of an intervention. The classification provides researchers and practitioners with a common framework to develop and evaluate interventions aimed at fostering employees' disconnection from work.

Keywords: constant connectivity, right to disconnect, detachment, organizational interventions, classification.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.8
ISBN 978-961-286-362-3

1 Introduction

Information and communication technology (ICT) affords employees with high levels of autonomy to decide how, when and where they work. 'Nomadic workers' (Cousins & Robey, 2005) work from a client's site, a hotel room or from home instead of from a traditional office. The flexible work environment also leads to extended availability for work which has negative effects on the employees' well-being (Dettmers, Bamberg, & Seffzek, 2016) and the organization (e.g., Ferguson et al., 2016). Although companies increasingly expect this near 24/7 availability and sell it as part of their service (Mazmanian & Erickson, 2014), the negative effects have alarmed managers and human resource departments. As a result, organizations and governments are discussing the introduction of "the right to disconnect" (Hesselberth, 2018). France has been the first country that enacted a law regulating employees' availability after work-hours (Hesselberth, 2018). Companies such as Volkswagen (VW) and Daimler have reduced their employees' availability through banning emails after regular business hours or deleting emails during the holiday (Smith, 2017).

As companies are only recently dealing with the dark side of extensive connectivity, research on organizational interventions is limited. Until now, there is no systematic way of comparing disconnectivity interventions and assessing their success. This paper develops a classification of those interventions to assist organizations in identifying the most effective intervention for their employees and their organizational culture. Drawing on the theory of psychological detachment (Sonnentag & Fritz, 2015), I discuss the likelihood of success of disconnectivity interventions. To my knowledge, this paper is the first that applies psychological detachment as a theoretical frame to organizational interventions that target the right to disconnect. It paves the way for an empirical validation of the classification that provides researchers and practitioners with a framework to develop, compare and evaluate these interventions. It further extends the limited research on employees' strategies for coping with extensive connectivity by considering strategies with that organizations can support their employees' detachment from work.

2 Theoretical Background

2.1 Connectivity

In the political and organizational discourse, the right to disconnect has been understood in terms of disconnecting from work-related technology (Hesselberth, 2018). However, connectivity covers more than the mere technical connection to work. Researchers understand connectivity in various ways, for example as a technical connection to a device (Al-Dabbagh, Scornavacca, Sylvester, & Johnstone, 2015), extending working hours (Dettmers et al., 2016), the internal need of being connected to others (Bayer, Campbell, & Ling, 2016), or an organizational norm of 24/7 availability (Mazmanian & Erickson, 2014). I understand connectivity as the technical and social connection to work (i.e., the technical capability to access work whenever and wherever; and the social environment that expects and drives an extended availability to work). Connectivity is the socio-technical **potential** for information and communication and the **manifest** practices that emerge upon this potential.

Extensive connectivity is an elevated, nearly constant level of this connectivity. It can lead to emotional exhaustion (Xie, Ma, Zhou, & Tang, 2018), prolonged thinking about work (Cropley & Zijlstra, 2011), work-life conflicts (Ferguson et al., 2016) and an inability to detach from work (Derks, van Mierlo, & Schmitz, 2014). These individual effects are mirrored in negative organizational outcomes. For example, using a mobile device for work during family time is associated with higher burnout rates and less organizational commitment (Ferguson et al., 2016). Well-being and recovery are important factors for the employees' productivity (Binnewies, Sonnentag, & Mojza, 2010). Organizations are therefore increasingly concerned regarding the connectivity practices of their employees and seek applications of the "right to disconnect".

2.2 The Right to Disconnect

Until today, France is the only country that has introduced a law for supporting employees' disconnection decisions. The law demands the enactment of "modalities by which employees exercise their rights to disconnect, and the setting up of company regulations on digital devices and tools" (Secunda, 2019, p. 28). It remains

unspecific, in that it neither prescribes explicit interventions nor specifies fines for incompliance (Von Bergen & Bressler, 2019).

While the French law provides employers with much room for interpretation, Germany has not introduced a law at all but is relying on voluntary self-regulation policies of employers (Secunda, 2019). As a result, German companies introduced specific measures that enable their employees to disconnect. VW reacted early in 2011, when they banned emails to company-provided smartphones after regular working hours. Their competitors Daimler and Porsche followed with similar regulations (Smith, 2017).

These examples demonstrate the challenge to define the degree of specification of disconnectivity measures. France enacted an unspecific law that could be ignored by employers due to the inexistence of fines. The specific German interventions might lead to even more stress for some employees due to not accounting for interindividual differences in the preference for work-life integration (Von Bergen & Bressler, 2019). As a one-size-fits-all approach is difficult, if not impossible, to develop, it is necessary to consider differences between companies, contexts, and individuals. Furthermore, an evaluation of the success of these interventions in terms of a comprehensive disconnection from work is important for the development and budgeting of further interventions. To date, organizational disconnectivity interventions mostly target the technical connection to work although connectivity also covers social expectations of extended availability and responsiveness. A successful intervention should therefore consider both, the physical disconnection as well as the emotional and mental disconnection from work. Psychological detachment (Park, Fritz, & Jex, 2011) provides a measurement of a successful disconnection.

2.3 Psychological Detachment

The theory of psychological detachment explains that demanding work conditions (e.g. time pressure, work overload) lead to strain reactions (e.g. increased heart rate, impaired well-being) (Sonnentag & Fritz, 2015). Individuals can only recover from work when they are not exposed to these stressors (Sonnentag & Fritz, 2015). Psychological detachment is defined as "refraining from job-related activities and mentally disengaging from work during nonwork time" (Sonnentag & Fritz, 2015,

p. 72). This definition emphasizes the importance of both, the physical and the psychological facet of switching-off. The physical dimension refers to being absent from work. This includes not only staying away from the office or desk but also not answering work-related emails on the mobile phone during nonwork time or not taking the work notebook on holidays. The psychological dimension refers to stop thinking about work after work hours. Psychological detachment is one of the best researched recovery strategies and relationships to job-related outcomes and psychological well-being have been empirically supported (Sonnentag & Fritz, 2015; Wendsche & Lohmann-Haislah, 2017).

The detachment literature has identified antecedents of a successful detachment (Wendsche & Lohmann-Haislah, 2017) and has been increasingly included in discourses on technology-enabled extended availability for work (Cambier, Derks, & Vlerick, 2019; Park et al., 2011). Research has found that detachment strategies can be trained and thereby integrated into an individual's daily routine (Hahn, Binnewies, Sonnentag, & Mojza, 2011). Researchers therefore called for organizational policies that support individual detachment strategies (Cambier et al., 2019).

In the following paragraphs, I discuss different types of interventions and develop a classification that helps to identify which type is likely to be successful for which situation and company. Successful in this context means a comprehensive detachment from work, physically as well as mentally.

3 Developing a Classification of Disconnectivity Interventions

Organizational interventions are "planned, behavioral, theory-based actions that aim to improve employee health and well-being through changing the way work is designed, organized and managed" (Nielsen, 2013, p. 1030). As detachment refers to both, disconnecting from physical stressors (i.e. organization and design of work) and mental stressors, interventions should also include changing the way work is experienced by the individual.

3.1 Method

Based on a literature review on existing taxonomies of organizational interventions, I collected dimensions and classes of organizational interventions that have been identified previously. By applying them to the definition of connectivity, I selected those who are relevant in the context of an intervention that enables employees' detachment and developed an initial classification. In the last step, I analyzed interventions that have been already introduced (e.g. VW, Daimler, Porsche) according to the initial classification. I refined the dimensions and classes and developed the final classification. It is important to note here, that the classification represents a first attempt to systematize detachment interventions. Empirical data has to validate the classification.

I develop a classification based on three dimensions: the level at which the intervention occurs, the specific connectivity facet that the intervention targets, and the mechanism through which the intervention works.

3.2 Level – Individual or Organizational

A highly cited intervention taxonomy distinguishes four levels on that organizational interventions occur: legislative and policy level, employer and organization level, job and task level, individual and interface level (Murphy & Sauter, 2004). As the purpose of this paper is to evaluate organizational interventions, I focus on the employer and organization level. Employer interventions can be further distinguished into interventions targeting the whole organization and interventions targeting the individual employee (Martin, Karanika-Murray, Biron, & Sanderson, 2016). At the organizational level, interventions shape working conditions and psychosocial factors. At the individual level, interventions aid employees in responding to stressors (Martin et al., 2016). With interventions at the organizational level, management can prescribe or prohibit behaviors and introduce policies that are valid for the whole workforce or a large part of it. Examples are VW's approach to ban all email at a certain point (Smith, 2017) or changing organizational norms of a 24/7 availability by introducing charters or codes of behavior. At the individual level, organizations can encourage their employees to change their checking behavior, for example, through modifying smartphone settings so that they only get notified during a period they can determine themselves.

3.3 Target – Potential or Manifest Connectivity

Literature has distinguished organizational interventions into primary, secondary and tertiary interventions (Murphy & Sauter, 2004). Primary interventions aim at modifying job or organizational characteristics and thus eliminate or reduce the source of stress. Secondary interventions address the consequences instead of the source of the stress Tertiary interventions aim at the rehabilitation of employees (Murphy & Sauter, 2004). Applied to connectivity, primary interventions modify the technical and social affordances to extensively connect to work, thus, target the potential connectivity. Secondary interventions target the consequences of potential connectivity, the practices employees engage in, thus, the manifest connectivity. Tertiary interventions consist of helping employees to deal with the negative effects of extensive connectivity such as difficulties to recover from work (Park et al., 2011) or burnout (Ferguson et al., 2016). These interventions are rather subject to general rehabilitation interventions instead of specific disconnectivity interventions. I therefore include only primary and secondary interventions in the classification of organizational disconnectivity interventions.

Interventions with the target of potential connectivity aim at modifying the capability to connect technically and socially to work. This includes reducing the technical possibility of getting reached during the holiday such as Daimler's program "Mail on holiday" that deletes emails that are sent to employees who are on holiday (Von Bergen & Bressler, 2019). Reducing the potential social connectivity could be achieved by developing agreements specifying periods of unavailability of employees. Interventions targeting the manifest connectivity aim at modifying practices that have emerged upon the potential connectivity. The affordances of mobile devices can lead to practices such as frequent checking behavior (Oulasvirta, Rattenbury, Ma, & Raita, 2012). Social expectations can result in practices similar to performing work (Rosengren, 2019), where employees signal a high work commitment regardless of how much they are actually working. This might result in sending emails to managers late at night or in the email practice of "reply all" to show many people that they are working. These habits can be targeted by introducing email policies or even delete the "reply all" function (Pansu, 2018).

3.4 Mechanism – Technology or Social Detachment

Connectivity literature has understood the phenomenon as technical and social signals that are mutually influencing each other (Wajcman & Rose, 2011). Technical connectivity drives social connectivity since it enables the possibility to access work at any time so that expectations of an extended availability and short response times emerge (Dettmers et al., 2016). At the same time, employees might increase their technical connectivity due to the availability expectations. They signal an extended availability (e.g. an 'online' status in the chat program) to others, in as much as this work attitude signifies the image of a hard worker (Rosengren, 2019). Disconnecting from work is achieved by detaching from the technical connection as well as detaching socially from work.

Disconnecting technically refers to limiting or cutting the technical connection to work so that employees can neither access information nor be able to communicate with others. The above-mentioned intervention of banning emails that has been introduced by VW is an example of an intervention at the organizational level that leads to disconnecting from work technically. Another intervention might target the common trend of using the same device for work and private issues (Harris, Ives, & Junglas, 2012). A separation of the devices would loosen the "electronic leash" (Diaz, Chiaburu, Zimmerman, & Boswell, 2012, p. 500) that ties employees to their workplace. Disconnecting socially targets internal as well as external availability and responsiveness expectations. Interventions that work through social detachment are for example the concept of Predictable Time Off (Perlow & Porter, 2009), where employees are required to take a break, thus, they are expected to be unavailable. An overview of the classification with examples is illustrated in Table 1 in the appendix.

4 Discussion

The classification distinguishes dimensions and classes of disconnectivity interventions. As connectivity is a complex, multifaceted phenomenon (Mattern, Haines, & Schellhammer, 2019), interventions have different targets and are not equally suitable for every organization and situation. In the following paragraph, I discuss the likelihood of success for different interventions and factors that might influence the effectiveness of the intervention. Based on the definition of an organizational intervention, it is successful when well-being and health of the

employees are increased (Nielsen, 2013). A successful disconnectivity intervention should therefore result in an improved mental and physical detachment from work.

4.1 Success Factors

The classification helps to identify success factors for different interventions. Before introducing an intervention, companies should define what type of intervention they need to improve their employees' ability to detach. Interventions at the organizational level are only successful when they target general challenges that hinder the employees' ability to detach such as a high workload (Sonnentag & Fritz, 2015) or availability norms (Mazmanian & Erickson, 2014). Interventions at the individual level are successful when employees differ in their ability to detach due to factors such as segmentation preferences (Park et al., 2011). Employees who prefer strict boundaries and want to prevent work-home spillover are more likely to detach from work (Park et al., 2011) than those who appreciate an integration of both spheres and might engage in an extended technology use for work (Derks et al., 2014). The same preferences can be found among organizations, with some organizations promoting clear boundaries and others a work-home integration (Kreiner, 2006). Interventions at an organizational level are useful to target organizational integration norms. If only some employees report difficulties in disconnecting, it would be helpful to introduce individual interventions for those with a high integration norm.

The decision between targeting potential or manifest connectivity requires an examination of the current level of connectivity in the organization. Potential connectivity should be at a requisite level, thus, at a sufficient level for achieving tasks (Kolb, Collins, & Lind, 2008) which is dependent on the situation (e.g. a higher level is necessary in global teams that are operating across different time zones). Once a requisite level is achieved, interventions can target the individual practices that emerge upon the potential connectivity. Targeting manifest connectivity without considering first potential connectivity, does not treat the cause of the problem but only the symptoms. For example, restricting the practice of replying to all in an email in a situation of many possibilities and expectations to connect would only lead to workarounds via other tools.

Mechanisms of interventions interact and can enhance each other (Pawson, 2013). Disconnectivity interventions are therefore likely to be successful when they work through both mechanisms, social and technical detachment. A comprehensive disconnection from work is only possible when employees physically leave work and stop thinking about work (Sonnentag & Fritz, 2015). Thus, employees fully disconnect from work when they are neither technically tied to their work nor mentally or emotionally attached through availability expectations emerging upon social connectivity.

4.2 Limitations and Future Work

The proposed classification of organizational disconnectivity interventions is the first approach to this topic and will benefit from further research. Due to the complexity of the phenomenon of extensive connectivity, it is difficult to propose a one-size-fits-all approach. Organizations vary in size, culture, and industry, all of which can influence the fit between employees and interventions as well as the likelihood of success. Also, organizations are restricted in their actions due to budget decisions and the capacity of human resources for the introduction of those actions. Future research should validate the classification. A validation requires to systematically analyze various interventions that are already in place. This will include to collect information about the interventions from the companies' management to see whether there are differences between the interventions and whether they can be categorized according to the classification. To evaluate the success of an intervention, interviews and questionnaires regarding the detachment of the employees (e.g. Recovery Experience Questionnaire (Sonnentag & Fritz, 2007)) should be conducted.

5 Conclusion

This paper proposes a classification for organizational interventions that aim at enabling employees to disconnect from work. The classification aims at providing researchers as well as practitioners with a common understanding of intervention types. It can guide further research and the development and evaluation of disconnectivity interventions. The classification contributes to literature on connectivity that is only beginning to examine organizational interventions as discussions regarding employees' rights and needs to disconnect are recently

emerging (Hesselberth, 2018). I hereby add to the limited literature that takes a positive perspective and examines coping strategies for extensive connectivity (Russo, Ollier-Malaterre, & Morandin, 2019). I combine the psychological theory of detachment with literature on connectivity and organizational interventions. I hereby propose a means for evaluating the success of an intervention and provide theoretical backing for the development of such interventions. In addition to the theoretical contributions, this paper helps managers, human resource departments and occupational health practitioners to specify which intervention is suitable for the level and distribution of connectivity among their employees. This prevents a premature decision and increases the likelihood of success. Acknowledging that companies are not completely free in their choices of introducing interventions, the classification creates awareness of the necessity to clearly define the level, target and mechanisms of the intervention.

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Appendix

Table 1: Classification of Organizational Interventions

Dimension	Class	Example
Level	Individual	Detachment Coaching
	Organizational	Banning Emails
Target	Potential Connectivity	"Mail on Holiday"
	Manifest Connectivity	Delete "reply all" function
Mechanism	Technical Detachment	Separating business and private phone
	Social Detachment	"Predicted Time Off"

Perceived Limitations of Telemedicine from a Phenomenological Perspective

Michael Knop[1], Marius Mueller[1], Henrik Freude[1], Caroline Ressing[1] & Bjoern Niehaves[1]

[1] University of Siegen, Department for Business Information Systems, Siegen, Germany, email: michael.knop@uni-siegen.de, marius.mueller@uni-siegen.de, henrik.freude@uni-siegen.de, caroline.ressing@uni-siegen.de, bjoern.niehaves@uni-siegen.de

Abstract In the course of healthcare digitization, the roles of therapists and patients are likely to change. To shape a theoretical based process of technological transformation, a phenomenological perspective on Information and Communication Technology (ICT) is introduced. Therefore, this paper illustrates the benefit of a holistic view on patients and therapists to describe and explain phenomena concerning Human Technology Interaction (HTI). The differentiation between a measurable objective body and a habitual subjective body helps to evaluate and anticipate constituting factors of accepting telemedicine systems. Taking into account findings from a secondary analysis of semi-structured interviews we conducted with primary care physicians, we develop a phenomenological framework for HTI in healthcare. Our aim is to structure future research concerning design implications for ICT and the implementation of telemedicine systems in clinical and primary care.

Keywords: telemedicine, phenomenology, acceptance, human technology interaction, information and communication technology.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.9
ISBN 978-961-286-362-3

1 Introduction

As digitization of healthcare services proceeds, different challenges of care are going to be addressed by Information and Communication Technology (ICT), robots, sensory technology, or virtual reality (Krick et al. 2019). Therapists therefore face implementations of care-related technologies and are in need of balancing structural and technological change, professional identity, and a different relationship with patients (Fuller and Hansen 2019). Furthermore, the digitization of healthcare is linked to promises of efficient and innovative care (Hollis et al. 2015) as well as an increasing quality of medical treatments (Mutter et al. 2005). Telemedicine systems appear to play a significant role in the digitization of healthcare, as they are capable of reducing spatial and temporal limitations (Kvedar et al. 2014). Especially in rural areas, telemedicine systems might therefore address rising issues of medical undersupply as a consequence of demographic changes, age related multimorbidity (Demiris and Hensel 2008), and an exodus of healthcare professionals (Thommasen et al. 2001). Although many scientific results point out positive effects of digital technologies in healthcare, theoretical founded research is still rare (Garrett et al. 2018). To shape a theoretically driven process of technological change that can be accepted and catalyzed by both therapists and patients, it is of great interest to understand design-implicating factors of digital technology while taking into account the highly complex patient-therapist relationship and its constituting characteristics. Öberg et al. (2018) e.g. illustrate the necessity to reflect digitization processes in clinical care, as digital technologies are able to cause temporal stress of therapists, affect the relationship between care-giver and care-receiver, and reshape the professional identity of therapists.

To base upcoming research on a theoretical fundament, we propose a phenomenological framework that we build from qualitative empirical insights on Human Technology Interaction (HTI) to formulate implications for design as well as perceived limitations of technology. In IS research, phenomenological perspectives seem to be existent but are underdetermined. For instance, Schultze (2010) states that "the body serves as a frame of reference for the neural processes of the mind" (p. 436) whereof she indirectly proposes a distinguishable nature of the person. In contrast, when Schultze (2010) mentions "what we know about the world is embodied" (p. 436), a phenomenological view on human experience is reflected. Therefore, the objective of this paper is to develop a theoretical framework based

on phenomenological assumptions concerning the interaction between humans and healthcare technologies. Assuming that a phenomenological perspective on HTI is already existent in IS research, but not differentiated appropriately, the following paper discusses our process of building such a theoretical framework and explore potentials for describing, explaining and predicting relevant phenomena in IS research.

2 Theoretical Background

Phenomenology can be considered a philosophical perspective on the process of gaining knowledge. It might as well be described as a method to obtain ἐπιστήμη (epistimi), which can be translated to 'realization' or 'science'. Stating an insuperable difference between a logical deduction concerning a phenomenon and the real state of the phenomenon, the epistemic objective is translocated from the phenomenon itself to the process of its understanding (Husserl 2019). From this paradigm, phenomenology has affected the development of several scientific methods to collect and analyze data, especially in qualitative research (Neubauer et al. 2019). Therefore, in the research of HTI in healthcare, phenomenology is foremost utilized for methodological issues (Newland et al. 2018; Rosenberg and Nygård 2017). Derived from its general perspective, phenomenology can be applied to scientific research in terms of a theoretical framework as well. It promises an understanding and explanation of human experience, e.g., a patient's experience of a digitally assisted attendance at a physician's practice. Carel (2011) explains the phenomenological view on human experience implying that experience is *"founded on perception"* (p. 35), where *"Perception [sic!], in turn, is itself embodied activity"* (p. 35). In this manner, perceived stimuli of a patient can be seen as contextual and interpretable (Liberati 2019), as well as bodily manifested (Mingers 2001). While enhancing a therapeutic process through digital technology, one might ask:

How exactly does a digital transformation change the perception and the experience of therapeutic activity of patients and therapists and are phenomenological implications useful to formulate boundaries of digital technology in healthcare?

To understand the impact of these implications completely, it is necessary to describe the theoretical interrelation between a phenomenological perspective on human experience and the meaning of presence for mediated interaction between humans. The concept of presence has been used for decades in IS research to objectify the human experience of virtual worlds. Lombard and Ditton (1997) conclude that presence has several facets but can be basically defined as *"the perceptual illusion of nonmediation"* (section 6). The definition of Lombard and Ditton (1997) therefore implies a close relationship between presence and perception. Further, considering their conclusion on presence as a multidimensional construct, the dimensions transportation, impression of translocation, and immersion, the degree of submergence into an artificial environment, appear to be one of the most important characteristics for telemedicine mediated patient-physician interaction (Skalski 2011). In the context of healthcare, several studies emphasize the importance of presence for clinical effectiveness and consider presence a main constituting factor for a realistic artificial environment (Garrett et al. 2018; Londero et al. 2010; Price and Anderson 2007; Riva et al. 2002; Viciana-Abad et al. 2004). To ensure a multidimensional feeling or sense of presence, the creation of a mediated reality is oriented on an asymptotic convergence of the artificial and the real world (Heeter 1992). Similarly, perception can be thought of as a multidimensional construct as well. Loomis (1992) argues for a more subjective view on perception while stating that the 'real' world is generally mediated, which leads to the differentiation of naturally and artificially mediated worlds or environments. The realization of a world constructed through our senses (Loomis calls it the *"phenomenal world"*) helps us to understand why technologically mediated experience is capable of activating an actual sense of perception. Nonetheless, it is important to note that there still is a difference between a natural, directly mediated interaction and an artificially, technology-driven interaction. A phenomenological perspective on such a complex interaction helps to enlarge our understanding by expanding the interrelation between presence and perception through the relevance of experience, e.g. a diagnostic or interventional process. From a phenomenological view, experience itself is bound to the bodily characteristics of humans because the body is the foundation of our perception (Carel 2011). The subjective nature of perception, that can be deduced from Loomis (1992), and the corresponding subjective nature of experience emerging from the phenomenological perspective, lead to the *"body as lived"* (Carel 2011, p. 33): an impression of the human body that can only be experienced and is highly contextual. Nonetheless, measurement and

normalization of the human body creates an objectiveness of the body. The result is a dualism of the human body (Carel 2011). Although techniques and technologies exist to measure objective data of the human body (that is medical data), an interpretation of the data is closely linked to an experience of such a measurement. In our context, the relationship and interaction between physician and patient creates a defined space for a joint experience. Findings from our empirical investigations therefore reflect the distinction of a subjective and objective body and help us understand that the use and acceptance of specific technologies, such as telemedicine systems, are embedded in specific contexts.

3 Method

In our primary study to explore factors influencing a digitally enhanced relationship between patient and therapist (Mueller et al. 2020) we conducted seven semi-structured interviews with primary care physicians in rural areas to explore their perception on healthcare digitization, especially on potentials of telemedicine systems. Therefore, our major focus of the interviews was physicians' technology acceptance of such telemedicine systems. The interviews took 75 minutes on average. We engaged three female and four male interviewees. In our convenient sample, age ranged between 41 and 66 years (mean 52), while job experience ranged between 15 and 34 years (mean 25). In the main part of our interviews, we discussed the use of three different telemedicine systems (capable of 1. basic audio-visual communication, 2. audio-visual communication and real-time transfer of medical patient data via specific sensors, 3. the aforementioned features, but with automatized pre-analysis of medical patient data). To explore circumstances under which therapists tend to accept or reject the implementation of digital technology, we asked the participants about their hypothetical use of these telemedicine systems in their own practice. Exemplary questions were *"What kind of benefits or risks do you expect from a telemedicine system?"* or *"Under which circumstances would you likely accept such a telemedicine system?"*. In our process of primary analysis, we noticed that physicians basically tend to reject a specific telemedicine system when they had the impression that the telemedicine system limited their own sensory perception of the patient (Mueller et al. 2020). To follow up on our impression that a limited perception through digital technology might lead to a physician's rejection of telemedicine systems, we evaluated the key concept of limiting factors concerning telemedicine system use separately. Originally following an approach with three steps of coding

(open, axial, and selective coding) (Corbin and Strauss 2015), we therefore conducted a second, informed analysis of our transcripts and filtered codes that represented limitations of telemedicine systems perceived by physicians. We then examined the content-related accordance between our secondary findings and our theoretical prepositions explicated in section 2.

4 Findings

As an important insight of the conducted interviews and a result of our secondary analysis, therapists mentioned the importance of a bodily presence of the patient to guarantee therapeutic success. We noticed that therapists considered the absence of bodily presence a main negative aspect of telemedicine systems. Participants especially viewed the inability to make bodily contact as one factor limiting their perception of the patient: *"You are feeling it, don't you? And that's absent in a video […] you can't touch [the patient]."* (Interviewee 1) or *"Because personal contact is very important, especially for elderly patients or those in need for home visits being helpless* […]" (Interviewee 7). Noteworthy, the first part of interviewee 1's quotation points to an intuitional aspect of medical care, reflecting the phenomenon of the (experienced) therapist's ability to bring several complex medical information into a relevant diagnostic concept. The ability to touch a patient seems to be a part of this process. As interviewee 7's statement claims the importance of bodily contact as well, another dimension can be noticed from the quotation. An additional social dimension can be considered since humans express their social relation with bodily contact (i.a.). Besides the described general necessity to be able to touch a patient, two participants mentioned the importance of physical contact to better diagnose a patient: *"When someone recently said, 'I felt dizzy and weak…' - that might be anything. For this, I have to auscultate heart and lungs, I have to palpate him."* (Interviewee 5) or *"That is most important, to palpate* […]" (Interviewee 3). The quotations of interviewees 5 and 3 point out an important fact with regard to the process of a primary care physician's diagnostic process. To actually make a possible diagnosis from relatively unspecific data, i.e., a subjective expression of symptoms made by a patient, the characteristics of diagnostic technologies (e.g., auscultation or palpation) require a direct physical contact to the patient. Therefore, these quotations complement the already mentioned aspect of intuitional affected diagnosis with the physical measurement and interpretation of patient-related medical data. Although intuition describes an opaque process, auscultation or palpation can be viewed as mostly structured and standardized

diagnostic processes. Interestingly, this leads to the impression that diagnostic (and interventional) processes are composed of subjective and objective aspects. Furthermore, the bodily presence of patients in a conversation, especially at the first acquaintance, was considered important: *"To gather the medical history I would prefer to talk to a patient face-to-face."* (Interviewee 4) or *"It's not working without getting to know each other* […] *it's not possible without personal contact. I can't imagine being able to do sound work without."* (Interviewee 7). Although the interviewees did not mention detailed reasons for their statements, a social component of the patient-physician relationship evolves especially from the quotation of interviewee 7. The perceived necessity of a patient's bodily presence might be interpreted with regard to the already mentioned complexity of diagnostic processes. To make a reasonable diagnosis, physicians need to gather contextual information about a patient. Especially interviewee 7's quotation leads to the impression that without bodily contact, a reconstruction of a patient's relevant living conditions is not adequate.

5 Discussion

Following the interpretation of these statements, the perceived limitations of telemedicine technology include (1) a bodily absence of the patient in terms of a lack of body signals, possibly irritating the intuitional perception of the therapist, (2) an inability to shape the social relationship between patient and therapist through bodily contact, and (3) an obstacle to measure necessary physical parameters of the patient. As a constituting factor of a (subjectively perceived) successful relationship between patient and therapist, bodily contact might be something digital technology is per definition not able to replace. A phenomenological perspective on these issues helps to understand that the difference between bodily contact and biomedical measurements in medical care can be used to formulate implications for technological design as well as a reflective orientation for the process of digitization in healthcare. Carel (2011) differentiates an "objective body" and the "body as lived" (p. 33). Both impressions of the body are connected. The "objective body" can be associated with primarily physical characteristics (the auscultation of lungs, measurement of blood pressure etc.) and the "body as lived" with habitual, social, and subjective characteristics. In real-life experience of a person, it seems clear that these two impressions or perceptions of the body cannot be fully separated.

Considering the cited statements of the participants, the perceived limitations of telemedicine technology (regarding the interviewed physicians) can be differentiated. First, there are concerns about the ability of telemedicine technology to render complex physical signals of a patient, associated with the objective body. To counter underlying assumptions of decreasing quality of care and negative effects on the patient-physician relationship, the design of technological artefacts mainly has to consider questions of feasibility and practicability. Second, there are concerns about the ability of telemedicine technology to shape a bodily relationship between patient and physician, associated with the subjective body. In accordance with our theoretical explanations, we propose the following theoretical framework to explicate a phenomenological perspective on our objective:

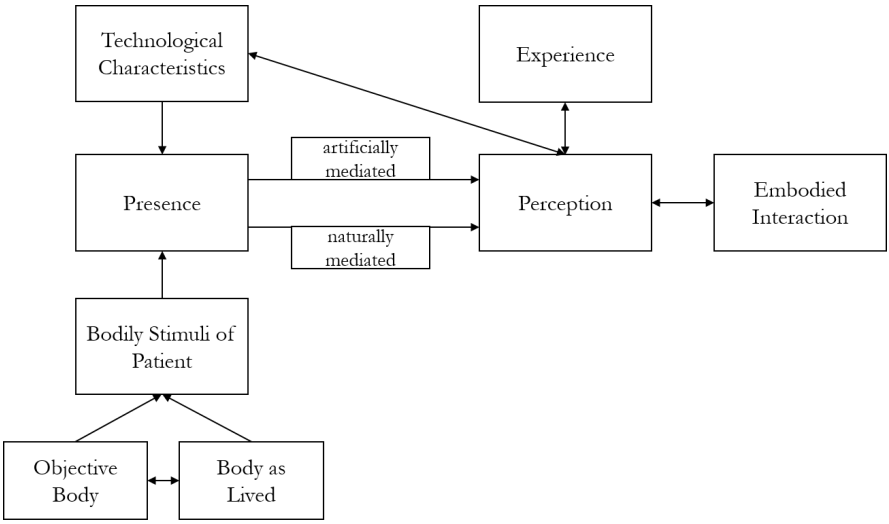

Figure 1: Therapeutic Interaction between Patient and Physician from a Phenomenological Perspective in the Context of Telemedicine

From Figure 1, the meaning of a phenomenological perspective on patient-physician interaction and its technological moderation can be derived. First, the differentiation of an objective body and the body as lived helps to understand that the presence and the perception of a patient depends on a contextualization or interpretation of objective medical data (concerning the objective body) through the entirety of bodily stimuli: feelings, emotions, or self-interpretation of a patient are substantial factors to form presence and the perception of a physician. Second, technological

characteristics and boundaries change the way physicians perceive the presence of a patient: e.g., visual and auditory quality of telemedicine systems affect an interactive experience of patient and physician. Technological characteristics are able to shape the perception of a physician through artificially mediated presence or in a natural way. Third, perception is bound to our own bodily senses and therefore affected by our embodied interactions. Finally, the interaction between patient and physician (processes of diagnosis or intervention), based on perception, can be considered a bodily experience more than a technological process.

As a result, to evaluate the acceptance of telemedicine technology (in context of both patients' and physicians' use), an important factor from a phenomenological perspective is the context in which the technology is embedded. A separation between reason of design and implementation of technology therefore appears irrational. To anticipate technological acceptance, it is reasonable to consider questions like: what appears to be the main purpose of a specific telemedicine system? Is the telemedicine system used to extend primary care or is it used to replace bodily contact between patient and therapist? From a phenomenological perspective, we deduce two different insights from our findings: (1) the replacement of bodily therapeutic processes with technology mediated processes possibly causes a physician's discontent or resistance to use such a technology. This might be evened through a preferably perfect illusion of bodily interaction. (2) The replacement of a therapeutic process concerning the subjective body of a patient (e.g., the meaning and interpretation of medical data) with a process concerning the objective body of a patient (e.g., algorithm-based thresholds of medical data for medical interventions) possibly causes a physician's discontent.

6 Conclusion and Outlook

A phenomenological view on digitally enhanced healthcare inspires a reflective discussion about essential constructs of technology use, such as embodiment or presence in the context of telemedicine systems, and their importance for practical implementation. While phenomenological research methods are already present to explore patients' experiences with healthcare technology (Kallmerten and Chia 2019), a phenomenological interpretation concerning antecedents of technology use constitutes an innovative theoretical approach to interpret the interaction between humans and technology. In our context of telemedicine use to overcome spatial and

temporal limitations of primary care in rural areas, a phenomenological approach demands a differentiation of specific functions of a telemedicine system. The reflection of human experience that is closely related to our bodily existence, leads to specific implications. The following principles can be interpreted as the most important ones for practice: (1) be careful about replacing a partial process of therapeutic interaction that involves bodily experience with a technology mediated interaction that is not capable of a(n) (almost) perfect illusion of bodily experience. (2) be careful about replacing a partial process of therapeutic interaction that affects both the subjective and the objective body of a patient with a technology mediated interaction that is only capable of affecting the objective body of a patient. These principles occur through (1) the importance of a bodily dimension of human experience and (2) the importance of a contextualization of objective data in medicine. Antecedents derived from these principles might be helpful for both research and practice.

Taking into account the provocative nature of our findings, we are aware that the relatively small sample size of our qualitative research limits the validity of our proposed principles. Hence, for future research, we have to examine the empirical validity of our findings. In a further study about optimization of physician-assistant-delegation, we are going to explore underlying patterns of perceived usefulness through asking healthcare professionals to sequence both everyday and innovative technologies. In a subsequent process, we then use multidimensional unfolding to explore physicians' and physician assistants' perception of similarities and dissimilarities between these technologies. Through additional qualitative interviews with physicians and physician assistants, we like to develop a more differentiated model of our phenomenological approach that can be tested deductively in a comprehensive study. Furthermore, preliminary data from interviews with patients that have been part of telemedical treatment promises additional insights on theoretical relevance from a contrary perspective. Regarding our joint results, we are intending to develop a comprehensive phenomenological framework of HTI to structure future research concerning design implications of ICT and the implementation of telemedicine systems in clinical and primary care.

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THE USER EXPERIENCE OF PERSONALIZED CONTENT

THOMAS MEJTOFT[1], TONJE LINDMARK[1],
ULRIK SÖDERSTRÖM[1] & HELEN CRIPPS[2]

[1] Umeå University, Digital Media Lab, Umeå, Sweden, e-mail: thomas.mejtoft@umu.se, ulrik.soderstrom@umu.se, lindmarktonje@gmail.com
[2] Edith Cowan University, School of Business and Law, Perth WA, Australia, e-mail: h.cripps@ecu.edu.au

Abstract Content in digital services is often filtered for users based on individual preferences with the possible consequence of creating a state referred to as a "filter bubble". The objective of this paper is to examine which of a user's inherent needs that are important to satisfy when a user is consuming personalized content in a digital service. The paper uses a survey to measure the need for autonomy, competence and relatedness of the Self-Determination Theory when users are consuming filtered content in digital services. The results show that the investigated services fail to satisfy all needs. A satisfactory user experience should include the opportunity for the user to satisfy the need for autonomy, competence and relatedness. For autonomy, transparency of filtering and choice about filtering should be offered. For competence, it is essential to offer content that the user can learn from, and also provide the right amount of choice throughout the service. The danger of filter bubbles is not personalization, but to remove choice about personalization.

Keywords: filter bubble, user experience, facebook, instagram, netflix, spotify.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.10
ISBN 978-961-286-362-3

1 Introduction

Nowadays, it is a common practice to filter content for users based on individual preferences, so called personalization. One way of personalizing content is to base suggestions on users' previous choices and behavior (Schubert & Koch, 2002). However, one consequence of this is a state where the user is consuming similar content to that which the user has been exposed to before – so-called "filter bubble" (Pariser, 2011a). The existence of filter bubbles and their potential impact on people are often discussed from a societal viewpoint (Zuiderveen Borgesius et al., 2016). The agreed upon problem with filter bubbles is that people who operate within them get biased information and this in turn poses a threat to democracy (Pariser, 2011a; El-Bermawy, 2016). A filter bubble's subtle effect makes it difficult for the user to recognize its influence and prevent being caught in it (Pariser, 2015). Therefore, the responsibility does not lie with the user but with the companies that provide digital services and implement filtering (Zuiderveen Borgesius et al., 2016). In order to present content that is not harmful to the user in the long run, the basic needs of the user must be known. The objective of this pilot study is to examine which of a user's inherent needs that are important to satisfy when a user is consuming personalized content in a digital service. Understanding those matters, this article aims to describe what qualities and behavior regarding autonomy, competence and relatedness to consider for personalized content in aspects of user satisfaction.

2 Theoretical Framework

The information available on the internet today can be overwhelming, Facebook, alone, have over two billion active users who produce different content. To deal with all this content personalized filtering is common using algorithms to create the most accurate user profile in order to predict the user's next move and what content the user wants to see (Pariser, 2011b). Personalization of content has the primary goal of enhancing the user experience and increase the likelihood of repeated visits and usage of digital services (Schubert & Koch, 2002). Personalization is achieved when a system tailors the user experience by matching metadata of products or services with metadata of user profiles. It is common to log self-revealed preferences, socio-economic status, user ratings, relationships to other users, previous interactions and purchases. Nearly every company that gathers this type of data use it for personalization, Amazon, Spotify and Netflix give recommendations

based on users' activity. This has also led companies such as Facebook and Google to be accused of personalizing content even though their underlying mechanism for filtering is kept a secret (Hern, 2017). Hence, the effects on users of algorithm-based personalized content can be negative as they can cause filter bubbles (DiFranzo & Gloria-Garcia, 2017). The bubble occurs when systems serve each user with unique information thus altering the way users are consuming ideas and information (Pariser, 2011b). Users are then no longer exposed to outside options and views; they are operating within bubbles that only reflects parts of the whole. This leads to heavily opinionated audiences and narrow perspectives of opinion (Zuiderveen Borgesius et al., 2016).

The Internet have provided users with increasing choices on what media to consume. However, the power is still not held by the users but with the companies that control what the users consume (Pariser, 2011b). In this way, filters illustrate choice. The more filtered and personalized content is, the less is left for the consumer to choose. Filter bubbles can also be difficult to pierce through (Pariser, 2011b). Not only does the user have to perform deliberate actions to burst the bubble, it also demands an awareness from the user about being exposed to filtered content (DiFranzo & Gloria-Garcia, 2017). The actual existence and impact of filter bubbles have been debated for some time now. However, there has been a large upswing since 2016 after the result from the EU Referendum in U.K. and the U.S. presidential election. The predicted results of these events were far from the actual outcomes, and Social Media was directly accused of this (DiFranzo & Gloria-Garcia, 2017). In 2018 it was discovered that the company Cambridge Analytica (now shut down) had a role in this by selling data about Facebook users to political campaigns that were able to target specific groups based on the data (Solon, 2018). Due to the secrecy of large actors like Facebook and Google, it is generally hard for outside researchers and investigators to conduct empirical research on filtering algorithms (Zuiderveen Borgesius et al., 2016). However, in a highly criticized study Facebook has conducted its own studies on filter bubbles, claiming a not significant existence (Ingram, 2015).

Another important aspect regarding this area is the user's curiosity and exploration. The definition for curiosity is a need, thirst, or desire for knowledge. Exploration refers to all activities concerned with gathering information about the environment (Edelman, 1997). Curiosity can be interpreted as form of arousal, which arises from

the perception of a gap in knowledge or understanding (Loewenstein, 1994). Curiosity can also change focus or end abruptly. Despite its volatility, curiosity can be a powerful motivational force. It has a close connection to motivation, which is the direction and persistence of behavior. Every time we are using a feature in a design, we have expectations and those expectations can be met in various degrees. This is one cornerstone of what is generally called user experience (Norman& Nielsen, n.d.) and when constructions features, the goal is, most often, to create a high user satisfaction. Hence, satisfaction is the "condition of having a desire or need fulfilled (Cambridge Dictionary, n.d.). Previous research has shown close likes between user satisfaction and motivation, e.g. the Self-Determination Theory (e.g. White, 2015)

2.1 Self-determination theory

Self-Determination Theory (SDT) is a macro-theory of motivation within psychology and has derived from empirical research of motivation. It concerns human motivation, personality, and optimal functioning in a social context. SDT uses psychological needs for explaining goal directed behavior. A critical effect of pursuing goals is to which degree people are able to satisfy their innate psychological needs. Three primary needs are essential in SDT - Competence, Relatedness and Autonomy (Deci & Ryan, 2000). Being able to fulfill these needs has a positive effect on psychological health, while the opposite results in negative effects. All three needs are inherent in humans; however, they are not automatically activated. To be actualized they need to be activated and nurtured by stimuli from the subjects' social environment (Deci & Ryan, 2000). A study about the correlation between choice and the level of autonomy (Deci, 1971) led researchers to develop the theory of self-determination (Zuckerman, 1978) that discuss two types of motivation - Intrinsic, when doing an activity for its inherent satisfactions, and extrinsic, when the activity is done to attain some separable outcome.

Autonomy and choice. Intrinsic motivation is a strong force when it comes to nurturing the needs of the integrated self (Deci & Ryan, 2000). It is a fragile balance as offering extrinsic reward for intrinsic motivational behavior decreases the sense of individual autonomy (Deci, 1971). When intrinsic motivation is controlled by external means, the autonomy becomes undermined. Research shows that the participant who have to make more choices also have an increased level of intrinsic

motivation to the task, and therefore an enhanced feeling of autonomy (Zuckerman, 1978). More recent research on choice has shown that it is not the mere act of choosing that triggers intrinsic motivation, but whether the content of the choice aligns with the participants self and personal goals (Katz & Assor, 2006). Further, results differ between picking and choosing. Picking refers to choice without preferences, and is less motivating than choosing. For choice to be motivating, the choices should differ markedly in relevance for the participant. At least one of the alternatives has to be more relevant, interesting or important (Katz & Assor, 2006). But the actual consequence of the choice is not important. Even choices that appear trivial, are experienced as meaningful by the participants.

Competence and choice. Choice also affects competence (Katz & Assor, 2006). According to SDT, more choice is increasing competence, but research has shown that the feeling of competence is dependent on the complexity of the choice. If the choice environment is complex, subjects tend to choose the most "default" option, not choose at all or ask for outside expertise. The feeling of not being able to comprehend choice decreases the feeling of competence. Since choices that are too easy also undermines motivation, an intermediate level of choice is optimal.

3 Method

This pilot research is based on an online survey that assesses the individual's awareness of and effect on them of personalized content. The survey also investigated the interplay between filtering and the three needs for competence, autonomy and relatedness. Questions about choice are based on the streaming services, Netflix and Spotify, as recommendations from those system were relatively easy to spot and measure. Questions about more subtle filtering are based on the social media platforms, Facebook and Instagram, where filtered content appear in newsfeeds. The users were to choose the service in each category that the user felt most familiar with. The survey was developed by using guidelines for collecting data (Law, 2017) and consisted of both closed (Likert scale) and open ended questions. The targeted group was students that have experienced the transition from regular content to filtered content. The survey received 22 responses (30% female) and the participants were 18-34 years of age.

4 Results and discussion

The results were even between choosing Facebook or Instagram as the most used application. 20% claimed to spend less than 10 minutes a day on their chosen newsfeed application, and 30% spend more than an hour a day. It is suggested that the difference regarding Facebook and Instagram are probably not because of levels of filtering but due to the purpose of the applications being different, the answers that were more similar are of more interest and, hence, discussed below.

4.1 Filtering in newsfeeds

Autonomy. Since people were somewhat addicted to Facebook and Instagram, users do not completely act out of their own interests when using these applications. That is enforced by the fact that users even felt bored while scrolling the feeds. Acting out of one's interest is a key factor for satisfying the autonomy. Filtering can be a cause of the addiction, as the newsfeeds never appear the same when closing and re-opening the applications compelling users to return to see constantly loading new content on "refresh".

Autonomy and choice. The results show that Facebook users classified the content as more general than personal, and when scrolling they felt bored rather than entertained. Instagram users classified the content as more personal than general. However, they were also bored when scrolling the feeds. When participants were asked about their level of addiction, Facebook users were a little addicted to not feeling addicted at all. Some of the Instagram users were a little addicted, but there were users who also felt a stronger addiction to the application. Analyzing autonomy and choice, neither Facebook nor Instagram users felt they had control over the content in their newsfeeds, even though Instagram users technically choose whom to follow. This lack of control was evidenced by the participants' negative feelings about recommended posts and ads. There is a decreased amount of choice when a system is choosing the content leading to a decreasing the feeling of autonomy and negative feelings.

Competence. If curiosity is triggered by consumption of the media content, intrinsic motivation to the task increases. That was the case from the survey, as users estimated that they sometimes or often investigated content further. Users also felt that the variety of content in the newsfeeds of Facebook and Instagram were poor,

or even very poor. A low variety means that the users are continually exposed to similar content, and therefore not learning from it. This leads to a scenario where a gap of knowledge is triggered by the content and creates curiosity. The user then investigates content further, but new content is similar to previous content. Hence, the goal of competence is not fulfilled.

Competence and choice. Instagram users thought it was very easy to find interesting posts or new people to follow. However, the fact that it was perceived as very easy can mean that the complexity of choice is to low, and that Instagram offers picking rather than choosing. According to the theory (Katz & Assor, 2006), picking is easier than choice, and the alternatives must differ markedly to be categorized as choice so in regard to choice, Instagram does not satisfy the feeling of competence. This relates to filtering in the way that picking someone to follow (direct recommendations, clicking a profile who interacted with a post in the newsfeed or using the explore tab) is based on who the user already follows, a form of self-imposed filtering. Unlike Instagram, Facebook users claimed that it was very hard to find interesting content, and that they had little influence on what was displayed in the feeds. This describes filtering at its worse in relation to user experience. To rate content as uninteresting is a result of the user not learning anything new and means that the user is not able to satisfy the need for competence. Moreover, the almost complete lack of choice within Facebook leaves the user with no room for customization after own preferences, and therefore competence is not at all fulfilled.

Relatedness. People felt that they could be themselves to some degree, but that their posts were not completely aligned with their own interests. One could argue that in an ideal world people would be able to be themselves completely on or offline, however, there are rules to adapt to in all social contexts. Posts can have boundaries of what is acceptable but if people are still able to integrate themselves into a larger social whole, the need for relatedness will be satisfied.

4.2 Filtering in Recommendation services

Many of the answers differed between Spotify and Netflix. In general, the respondents seemed more content with Spotify. One reason for that could be that it takes more commitment and time investment to watch a movie or series than listening to a song. Users might therefore have higher expectations of Netflix. 75% of the respondents spent more than 30 minutes a day on their chosen application.

Autonomy. Since both Netflix and Spotify users liked the services, usage of both services is an act that aligns with the user's integrated selves. It is not necessarily a contradiction that Netflix users rated the content as quite mainstream. It can either be that they like content that is aimed at a general audience, or that they fail to estimate that content actually is based on recommendations. Content that is based on the lower common denominator is a typical example of a filter bubble's effect. However, the survey is insufficient in describing which scenario that applies in this specific case. Neither does this contradict the level of autonomy. As long as the user is happy with consuming the content, it means that it is aligned with the user's interests. Users were happy with the recommendations in Spotify, meaning recommendations have a positive influence on autonomy. The level of autonomy was not quite as high for Netflix users.

Autonomy and choice. The mostly used features are recommendation services and search function within the applications. Spotify's "Playlist" and "Discover weekly" were the most used. Scrolling, search and "Popular on Netflix" were used the most among Netflix users. Though Netflix users classified the content as quite mainstream (not personalized), they still liked Netflix. Spotify users thought of the content ranged from medium to personal, and their opinions on the content ranged between okay to good. Spotify users were not united about estimating how much they could affect music recommendations. This can be a result of Spotify's hierarchy to present content; some users understand how to use it in order to get specific music recommended, and some do not. The level of intrinsic motivation to the task of choosing type of music was therefore individual. Netflix users were more united regarding the feeling of control and answered a three. None were likely to use Netflix recommendations to find something to watch, they would rather rely on magazines, websites or friends' suggestions. Conversely, a majority preferred recommendation services in Spotify to find something to listen to.

Competence. Both Netflix and Spotify users thought that the variety of recommendations was only okay, as was the case with Facebook and Instagram. A low variety means that the users are exposed to similar content and not learning from it. If the user only depends on recommendations, then there is not enough new input provided in order to satisfy the autonomy in the long run.

Competence and choice. A recommendation from the Spotify resulted in 60% often being positively surprised, the rest had not reflected upon this. 40% were positively surprised by a Netflix recommendation, 40% had not reflected upon it and 20% were negatively surprised. When entering Netflix homepage without anything to watch, it was common that the users were experiencing negative feelings like frustration or disinterest. Users were not experiencing curiosity. Spotify users were, contrary, were likely to investigate further based on a recommendation such as artist or albums, however their answers ranged across the whole scale. The rating between Netflix and Spotify users regarding their perception about choice and content differed markedly. 75% of Netflix users were unhappy with choice and content, and the remaining 25% were happy. In the case of Spotify, 72% of the users were happy with choice and content and only 28% were unhappy. Spotify users thought it was quite easy to find new music. Netflix users thought it was a little harder to find new movies or series. The answers on this section differed markedly between Netflix and Spotify as the way the applications present content also differs. There are more sections, menus and services within Spotify than Netflix. This can be the reason why 72% of the Spotify users thought "there's a lot to choose from and I always find something good", but only 25% Netflix users was felt this way This implies that the way things are displayed has an effect on choice. Even though the huge library, the majority of Netflix user's thought that "there is a lot to choose from, but nothing is good". That is why this result can be directly translated to the fact that the choice environment in Netflix is too complex or there is a mismatch in the recommender system and the individuals' tastes. As the content is filtered to fit individual preferences, the user still has to pick something within the filtered content. Motivation can more easily be activated through Spotify as their way of structuring content gives the user a choice (rather than a pick) on what to listen to. A scenario classified as choice can be "Should I let Spotify decide today, go with the Radio or perhaps with my own Playlist?". As for Netflix, there are less options that would be classified as choice but more of picking, as their recommendations system is closer

to a newsfeed format, with a scroll function for browsing different lists on the main page.

4.3 Awareness

In relation to the respondent's awareness of filtered content 54% thought they received some personal content, 38% thought they received mostly personal content and 8% thought they received no personal content. The respondents were generally fine with giving up their data to the respective service they were using, such as what they watch or what they listen to. However, they were expressed concerned about personal data being shared to other applications, or the sharing of personal data "other" than taste in music or movies. 87% had noticed a sudden change in their newsfeeds based on something they did in the application. Their reactions to sudden changes in their newsfeeds were mostly negative; many were annoyed at the applications assumptions, but also concerned, and some felt they were being supervised. Some respondents had noticed a shift to more mainstream content than previously and that their newsfeeds were becoming more homogeneous.

The filter algorithms that operate in the background (they do not inform user that content is filtered) are still evident to the user, usually by a sudden change of which type of content that is displayed, based on a user action. The users' responses to these changes tended to be very negative. While the users responded well to filtered content in the form of recommendations, the negative reaction to subtle filtering related to newsfeeds where the amount of filtering is unknown, and where perceived control of filtering and what content to be displayed is low.

5 Conclusions

The Self-Determination Theory has originally been applied to traditional social environments, but these days it is fair to say that a technological environment makes no exception for what is considered real, and that the technological environment can be classified as a social environment. The results of this pilot study show that connections between SDT and algorithm driven personalization is likely, and that in turn can serve as guidelines for creating a satisfactory user experience. It is important that the needs for self-determination are met, as they are not actualized themselves but need external stimuli. As technology is continuing to be integrated into our

everyday lives, it is therefore very important to include SDT when designing for a long-term satisfactory user experience. The digital service should provide autonomy that ensures the user has the ability to act out of own interests and values. By clarifying what is filtered, the users get a stronger sense of autonomy while using the digital service. It should also provide competence, meaning that the user should feel competent about tasks and overall usage of the digital service. This can be achieved by offering material that the user can learn from. If the digital service provides a social aspect, then relatedness should be considered as well to give the user opportunity to integrate the self into the social environment of the digital service.

The results point towards areas within SDT that are of importance in the digital context: (1) Transparency of filtering increases trust to the digital service, and that in turn enhances the user experience. When users are given the opportunity to actively be able to choose when to consume filtered content and when not to, users have an increased intrinsic motivation. Motivation is strongly connected to autonomy. The increased level is a consequence of the user being able to act out of own interests and values, at least to a larger extent than without transparency. (2) Choice. It is not sufficient to serve the user with personalized or filtered content and simply expect a great result. How filtered content is presented, and the complexity of the choice environment is of great importance. It cannot be too complex, or too simple, in order for the user to feel competent. The service should also offer choice instead of just picking.

The study does not indicate that filtering is dangerous to the user experience. It is rather how filtering is used that has an effect on users and whether their goals of in relation to self-determination theory can be fulfilled.

The results regarding the different answers between Facebook/Instagram and Spotify/Netflix show that it is clearly not only filtering that affects people's need for autonomy, competence and relatedness, but the overall content provided and it presentation within the application. Facebook has been accused of using algorithms that are targeted towards the human triune brain by promoting viral media and click baits. This could be investigated by performing a study based on competence from SDT. The results of this study give indications on the choices to be made by content providers in order to achieve a greater user experience. Further studies are required about users, filtering and choice in digital services.

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DO USER REVIEWS MATTER? EMPIRICAL EVIDENCE ON THE ROLE OF USER INVOLVEMENT IN APP PERFORMANCE

MIRIAM ERNE[1], ZHIYING JIANG[2] & VANESSA LIU[2]

[1] Sole Proprietor, Cyprus, e-mail: miriam.erne@googlemail.com
[2] Singapore University of Social Sciences, School of Business, Singapore, Singapore, e-mail: jiangzhiying@suss.edu.sg, vanessaliusw@suss.edu.sg

Abstract The extant literature often presumed that user involvement was positively associated with software performance. In the context of mobile applications (apps), user reviews were collected to enlighten app developers on improvement of app quality through identifying bugs or suggesting new features. However, the value of user reviews varied a great deal due to their unmanageable volume and content irrelevance. In this study, over 40,000 user reviews with 50 apps were analyzed to empirically examine the association between customer led improvement and the revenues from the apps. Our findings indicated that customer led improvement produced significant increase in quarterly revenues. Greater growth in revenues was also observed if the developers responded to the user reviews faster. These results showed empirical support for the value of co-creation of apps with users, as customers could contribute to continuous improvement of the apps by providing experienced-based solutions.

Keywords: user involvement, customer led improvement, user reviews, mobile apps, empirical evidence.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.11
ISBN 978-961-286-362-3

1 Introduction

Nowadays application distribution platforms such as Apple App Store and Google Play provide millions of different mobile applications (apps) to users. As of the fourth quarter of 2019, there were around 2.57 million apps for android users and 1.84 million apps for App Store users available (Statista, 2020). Survival in such a "hyper-competitive" mobile market was challenging to app developers (Comino et al., 2016). It is therefore becoming increasingly important for app developers to optimize app performance based on user needs (e.g., see Maalej et al., 2016; Maalej and Hadeer, 2015; Chen et al., 2014). One way to do so is through user involvement.

User involvement often takes the form of user reviews in mobile app development. Unlike regular reviews for products and services, user reviews for mobile apps have a more direct and influential impact over the life span of mobile apps. Poorly-rated or unpopular apps could be phased out very shortly after launch, resulting in a waste of development cost and effort. Most apps actively elicit customer comments as they are useful to the app developers, who might not always be able to spot a non-working feature. With so many different versions of smart phones and frequent software updates (e.g., iOS 10 and iOS 10.3.2), one app feature may work in one but not in another. Through spotting bugs, user reviews often offer valuable information to enable continuous improvement of the apps. Users could submit their feedback on their needs and experiences with an app like a missing feature or poor functionality (Khalid et al., 2015; Panichella et al., 2015). Complaints from users are actually of great value to further improvement of the app quality as they direct developers to be more customer-focused (Barlow and Moeller, 1996).

However, the number of user reviews received could be immeasurable and unmanageable. For instance, online gurus like Facebook could generate as high as at least 2,000 user reviews per day (Chen et al., 2014). The aspects covered in the reviews could be highly diverse, ranging from the price of the apps to the frequency of advertisements. Manual processing and management of these reviews is simply impossible, costly and overwhelming. More importantly, not all feedback is useful. Almost 65% of app reviews were found to be noisy and irrelevant (Chen et al., 2014). Some suggestions might be solely emotional and commercially infeasible, throwing little light on what concrete corrections could be made.

Most prior researchers focused on the development of analytical tools for categorization of user reviews (e.g., Maalej et al., 2016; Maalej and Hadeer, 2015), seldom questioning the actual benefits of the ideas from the user on app development. It was presumed that user involvement (in form of user reviews) could always lead to better app performance. Our study therefore aims to address this gap. Though the notion of performance is multifaceted and could refer to various aspects such as success, effectiveness, usability, comprehensibility, and satisfaction etc., our study adopted a financial approach and focused on performance in terms of revenues yielded from apps.

Specifically, we categorized and analyzed over 40,000 user reviews associated with about 50 apps. We conceptualized user reviews with bug-fixing suggestions as "customer led improvement" and examined its impact on revenues of apps. We also took into consideration the time taken for app developers to respond to the user reviews and examined the moderating role of developers' responsiveness.

The remainder of this paper is structured as follows: first, we will explain the conceptual framework and the related past studies. The research methodology and the data analysis procedure will then be presented. Finally, the findings will be discussed and the theoretical and managerial implications will be drawn.

2 The Conceptual Model

The development of our research model was grounded on the user involvement literature. It sought to explain the effect of user involvement on app performance. We relabeled user involvement as "customer led improvement" to align with the focus of this study on bug-reporting user reviews. Developer responsiveness was included as a moderating variable. Our research model is presented in Figure 1.

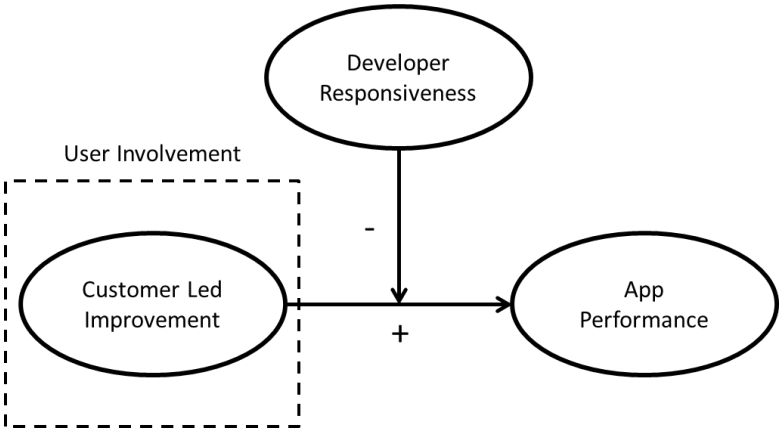

Figure 1: The Research Model

2.1 User Involvement and App Performance

The notion of user involvement was well documented in the literature, referring to the level of personal relevance and importance attached by users to the system (Barki and Hartwick, 1989). In broad terms, it is defined as "direct contact with users" (Kujala, 2003). User involvement may take different forms with varied levels and degrees. It can be informative, consultative or participative in nature (Kristensson et al., 2008). It is only helpful if certain involvement roles and development conditions are fulfilled (Ives and Olsen, 1984). These conditions include, who should be involved, which type of software with which the users should be involved, and in which stage (i.e., when) of the software development the users should be involved.

Recently, it was observed that customers had become more and more involved in the product development (Prahalad and Ramaswamy, 2013). User involvement was essential and indispensable for system/ software developers as it helped to collect more accurate user requirements and enable quality improvement, resulting in better fulfillment of user needs and higher user satisfaction (Kujala, 2008; Kaulio, 1998). User involvement was therefore recognized by previous researchers as beneficial to the improvement of quality and performance (Berger et al., 2005). Terms such as co-creation or co-design had emerged to describe the collaboration between developers and users. Other terms included quality function deployment (QFD),

user-oriented product development, concept testing, Beta testing, consumer idealized design, lead user method and participatory ergonomics (Kaulio, 1998). In the collaborative process, users may assume the roles of providers of information, commentators or objects for observations.

User involvement could be totally undesirable when technical expertise is needed. While the potential value of user feedback is not deniable, it may not always be economically justified for developers to translate user feedback into actual software features (Ives and Olsen, 1984).

2.1.1 Users vs. Customers in Mobile App Development

In the context of traditional system design, users may only be engaged in user need elicitation or user acceptance test. Their involvement is minimal in other phases of system implementation. In the context of mobile apps, app users are often customers in nature. They go through similar purchase cycles like a customer. For example, a user may perform app search and app comparison in the initial stage, followed by order placement (for paid apps) or downloading and installation (for both paid and free apps). After-sale service may take the form of making inquiries at the helpdesk of the app developers. As the roles of users and customers have become blurred in the context of mobile apps, the terms "users" and "customers" are used interchangeably in this study.

2.1.2 Customer Led Improvement

User reviews, if carefully and properly screened and processed, could be vital to ongoing improvement of app performance. For example, a user might point out specific problems of how usage of an app led to slowing down of his/her iPhone. With many varieties of smartphones available, it was difficult for app developers to detect bugs specific to a particular phone model. Frequent software updates (e.g., iOS) rendered it even more complicated to test functionalities and compatibility of apps. User reviews could be a good source to identify usability issues. Though some users may be tech-non-savvy, the problems experienced by them might never be foreseen in the development process. Their feedback could still help developers to enhance user-friendliness of the apps. Appropriately addressing user reviews could be of strategic value to developers (Gutt et al., 2019). In this study, we focused on

user reviews of the nature of bug-reporting. We conceptualized user reviews with suggestions on improvement as customer led improvement. It denotes reports from users about unwanted errors, bugs, annoying advertisements and other usability problems. Customer led improvement offer insights to developers to improve features and performance of apps, resulting in greater efficiency of development and higher user satisfaction (Kujala, 2008). Accordingly, we hypothesized that:

H1: Customer led improvement has a positive impact on app performance.

2.2 Developer Responsiveness to User Reviews

The time taken by developers to respond to user reviews on app improvement may matter (Vaniea and Rashidi, 2016). After a user submitted his/her feedback, he/she may tend to expect the developer to address the bug quickly. This is particularly important to individuals who are current users of the app. If the developer response is slow, the individual may continue to experience the bugs in the regular app usage and may eventually rescind usage or even uninstall the app. Conversely, users may tend to be more positive about the app if their concerns and problems were addressed promptly. The shorter the time taken to respond to user reviews, the greater the effect is the reviews on improvement of app performance. Accordingly, we hypothesized that:

H2: Developer responsiveness negatively moderates the relationship between customer led improvement and app performance.

3 Research Methodology

3.1 Research Context

The data was collected through a business intelligence company that retrieved panel data on a range of health and fitness apps, including the app user reviews and revenues generated from each app. Health and fitness apps were considered appropriate for our research focus as they tended to be used personally and users were likely to have more feedback on what improvement could be made. Another reason for the choice of these apps was that their target users were ordinary people. This should enable our research to be generalizable to other apps of general interest.

Only apps that had been active for at least one year were included in the sampling. Active apps should provide more valid results as it was common in the mobile apps industry that numerous apps could have been removed before their official launch. A total of 50 apps were selected for our analysis as their revenue constituted almost 75% of the total revenue in the health and fitness apps market. There were 189,527 user reviews available for these selected apps.

In order to measure the effect of user reviews on app performance, a specific research time frame was defined. Only reviews posted after the second last updated version and before the latest version of the apps were included in our samples. This enabled us to examine whether the user reviews led to improvement in the resultant update of the apps. The final sample consisted of a total of 40,619 user reviews, representing 21.4% of the total reviews associated with the selected apps.

3.2 Measurement

3.2.1 Customer Led Improvement

User reviews were used as proxies for improvement suggestions provided by customers. A subtraction and categorization process were conducted to identify the reviews that specifically pertained to improvement suggestions. Many tools were developed to support the search, screening, and extraction of useful information from user reviews. A review of the current literature showed that different tools were built with different mining objectives. Examples included MARK (Mining and Analyzing Reviews by Keywords) (Vu et al., 2015), MARA (Mobile App Review Analyzer) (Iacob and Harrison, 2013), ALERTme (Guzman et al., 2017), and AR-Miner (App Review Miner) (Chen et al., 2014). These tools made use of techniques like natural language processing, topic modeling, clustering and machine learning algorithms to search, classify, extract, group and rank user reviews based on pre-defined keywords or categories. In our study, Python coding was used to perform the screening of user reviews.

The screening took two steps. First, *generic* reviews were subtracted to isolate the *specific* reviews (Chen et al., 2014). *Generic* reviews were noisy and irrelevant reviews that did not provide any information on ways of improvement Examples of such reviews were "*by far the best app on meditation!*" and "*I love this app and have done since the*

moment I started using it. Potentially helped me get through a period of anxiety…". *Specific* reviews, on the other hand, were those that stated a specific actionable function, that is, a function that the app developer can fix or improve. A total of 7,654 specific reviews were identified.

Next, the specific reviews were categorized to shortlist the improvement-related reviews. Consistent with previous studies, reviews concerning bugs and too many advertisements (embedded in the apps) were considered customer led improvement reviews (Maalej et al., 2016; Maalej and Hadeer, 2015).

A bug review reported on an unwanted error in an app. It could be any kind of problems with the app, a crash, an error or a performance issue arising from programming failure by the developer (Maalej and Hadeer, 2015). Examples of such review were "*it's not letting me sign up and I deleted the app and re-downloaded it but it's not working*" and "*if you open the app in the watch it tries to connect for a minute (literally a minute) then crashes*". Keywords used to screen for bug reviews were "bug", "fix", "problem", "issue", "defect", "crash", and "solve" (Maalej and Hadeer, 2015).

A review complaining about too many advertisements indicated that ads popped up too frequently and caused user annoyance. Reducing the number of ads might be room for improvement for the developer. Examples of these reviews were "*paid for the ap. Still get ads pushed to me. Don't advertise to me if I paid the money for the non-ad version*" and "*The avalanche of ads makes it unusable unless you pay $3 each and every month*".

3.2.2 Developer Responsiveness

Developer responsiveness was measured by the time interval (number of days) from the first posted date of the user review to the update date when the bug was fixed or the advertisements were removed.

3.2.3 App Performance

App performance could be operationalized in a number of ways such as the number of downloads and app ratings etc. In this study, app performance was measured using the revenue generated from the app during the research time frame. This allowed us to examine the financial impact on the app developers more directly.

Revenues could include purchases of apps, micro-transactions within an app or in-app advertisement (IADV) (Ghose and Han, 2014). The revenues for each app was computed by a summation of the daily revenues for the research time frame.

3.3 Data Analysis

Regression Analysis was conducted to analyze the correlations in the measurement model. It enabled us to examine the significance and the magnitude of the impact from the independent variable (customer led improvement) on the dependent variable (performance in terms of revenues) (Mooi and Sarstedt, 2011).

As the data for customer led improvement took the form of written user reviews, steps were taken to convert the text data into numerical data. Each review was enumerated with a Python code respectively according to its match with the categories of "bug" or "too many advertisements".

4 Results and Discussion

The results of the regression analysis were presented in table 1 below.

Table 1: Results

	Unstand. Coefficients	**Stand. Coefficients**			
	B	**Std. Error**	**Beta**	**t**	**Sig**
Model 1 – Customer Led Improvement	7292.185	2456.607	.523	2.968	.005
Model 2 – Customer Led Improvement	29,805.931	12,470.637	2.139	2.390	.021
Moderator of Customer Led Improvement	-612.97	316.019	-1.736	-1.94	.058

The overall model was significant with a p-value of 0.007. H1 was supported (0.005), meaning that customer led improvement has a positive significant impact on app performance in terms of revenues. The overall R-square was 0.190, which was satisfactory and typical for exploratory research (Mooi and Sarstedt, 2011).

The moderating effect of developer responsiveness was only supported with an alpha of .1 (.058). It was negatively associated with the link between customer led improvement and app revenues. With shortened response time, the impact of customer led improvement might increase the revenues from $7,292.19 to $29,805.93, demonstrating the negative moderating effect of developer responsiveness.

5 Implications and Directions for Future Research

Our findings provided empirical evidence on the value of user reviews on bugs and other usability issues. It was challenging for app developers to identify all possible bugs in view of the jungle of different smartphone models and rapid software updates. It was more cost-effective to adopt the approach of management by exception and rely on user reviews to report on problems and errors. As customers acquired hands on experience with usage of the app, they were more able to suggestion solutions. In other words, co-creation of apps with users should be encouraged to enable continuous improvement of the app performance (Gustafsson et al., 2012). It should lead to strategic value to the developers in the long run (Gutt et al., 2019). It would be worthwhile for app developers to invest in management of user reviews.

We also tested the moderating effect of developer responsiveness on the relationship between customer led improvement and app performance. Though significant, the effect was not very strong. One plausible explanation is that developers may have to launch app updates very frequently after addressing each bug or improvement suggested by users. The recurring need to update the app may be annoying to users (Vaniea and Rashidi, 2016) and discourage them from the continued usage of the app. However, existing users might also grow impatient if bug fixing took excessive time and the non-workable features constantly caused disruptions. App developers should therefore ensure user reviews on improvement were properly addressed within a reasonable time frame (Schenchk, 2013; Armerding, 2012).

In future research, this study could be tested using other app performance measures, such as the number of downloads, user ratings, or app rankings. We only examined user reviews with bug-reporting. Other researchers could investigate the impact of user reviews with a different nature, such as those focusing on making innovative suggestions to the developers.

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Graph Databases and Robotic Process Automation: Achieving Improvement in Project Knowledge Management

Koch Oliver[1], Buchkremer Rüdiger[2] & Kneisel Evi[3]

[1] FOM Hochschule für Oekonomie & Management, mis Institute of Management & Information Systems, Frankfurt a. M., Germany, e-mail: oliver.koch@fom.de
[2] FOM Hochschule für Oekonomie & Management, ifid Institute for IT Management and Digitization, Düsseldorf, Germany, e-mail: ruediger.buchkremer@fom.de
[3] Technische Universität Chemnitz, Professur Personal und Führung, Chemnitz, Germany, e-mail: evi.kneisel@wirtschaft.tu-chemnitz.de

Abstract A key component for project success, particularly for complex and risky projects, is adequate knowledge management. The results of our feasibility study reveal the need for a dedicated analytical instance to better support virtual knowledge processes. We suggest combining robotic process automation (RPA) with a knowledge-focused graph database (GDB). Therefore, we present a prototypic approach for integrating this concept into project management routines.

Keywords: GDB, graph databases, RPA, robotic process automation, project knowledge management.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.12
ISBN 978-961-286-362-3

1 Introduction

Due to the current economic trends of globalization and digitization, today´s companies are faced with sometimes radical changes in their corporate environment (Astor et al. 2016, Friedrich 2016; Welter et al. 2014). In order to remain competitive and innovative in this volatile environment, companies have to adapt fast to changing markets and requirements (Ludwig et al. 2016, Schulz & Riedel 2016). Therefore, project-based work forms play a crucial role in the work organization of today´s companies because project work makes it possible to react fast and flexible on changing demands (Keegan & Den Hartog 2019; Turner & Miterev 2019).

The ability to recognize and use the relevant knowledge resources is central in project-based forms of work (Handzic & Durmic, 2014). Furthermore, it has been proven in numerous studies that inadequate knowledge management is a main cause of project failure (e.g. Desouza & Evaristo, 2004).

However, because of digitization and virtualization, the conditions and challenges of project knowledge management have changed. Particularly, higher amounts of information and knowledge available and increasing knowledge interfaces inside and outside of projects requires new technological solutions, in order to control critical knowledge flows as well as to keep transparency of available knowledge.

The current paper addresses this problem and suggests an integrative technological approach, which may support project knowledge management in virtual environments.

In a first step, the authors present a novel RPA-based framework for supporting controlling and integration of critical knowledge flows in projects. In a second step, the authors introduce a practical graph-based approach for knowledge mapping in projects. For this purpose, ontology-based knowledge maps are suggested to appropriately capture and organize project knowledge.

2 Challenges of Project Knowledge Management

A central base for the success of project management is effective information and knowledge management (Davidson & Rowe 2009; Gasik 2011; Handzic & Durmic 2014). In fact, one main reason for using project-based work-forms is the prospect of pooling and transforming specialized and dispersed knowledge to generate synergies and innovative services and products (Handzic & Durmic, 2014).

But, particularly due to the current economic trends of digitization and globalization, the conditions and opportunities of project-based work are changing radically (Turner & Miterev 2019). Examples are increasing virtualization of project work environments, new sources of information and knowledge, and knowledge intensification of processes. As a consequence, there are several upcoming challenges and tasks for project-based knowledge management, e.g., management of large amounts of data and information, controlling of virtually distributed knowledge flows, and the appropriation of novel technological tools and solutions.

Results of a current study on challenges and success factors of processual knowledge management in IT-projects confirm a variety of conditions that need to be considered when managing knowledge processes in project teams (Kneisel, Tietz & Werner 2020).

The mentioned study based on 27 in-depth interviews with members and leaders of 20 project teams, stemming from six German companies in the IT sector. Interviewees were invited to describe situations, which they perceived as success-critical for effective project knowledge management, in as concrete and comprehensive as possible.

Study results show that specific characteristics of project environments can inhibit effective knowledge processes. Particularly, heterogeneous information and knowledge channels, information overload, high amount of knowledge interfaces inside and outside of projects as well as spatial separation hinder sharing and integrating of project-based knowledge. Furthermore, localization and visualization of relevant sources of knowledge are challenging. Different networks make it

difficult to keep track of existing knowledge. As a result, existing knowledge resources – and relations are underutilized.

In sum, current results indicate two central requirements for successful project knowledge management. *First*, project knowledge management requires a central controlling function for coordinating flow and storage of dispersed knowledge. Knowledge flow must be controlled in a structured and targeted manner in order to successfully implement specialized and heterogeneous knowledge and expertise in project teams. Probably due to the lack of time and implicit control mechanisms, there is a high need for supporting explicit management of knowledge processes, e.g. by a central technical integrator and controller. At best, such a central controlling instance has a high level of meta knowledge about individual expertise, relevant team processes as well as rules and norms within the team, which helps to localize and coordinate relevant knowledge within the team. *Second*, there is a high need for capturing and visualizing relevant knowledge available, e.g., through knowledge maps. Knowledge maps may support identifying, organizing, and visualizing kind, ownership, and connectedness of critical knowledge in and outside the project. As a result, they help to find the most relevant knowledge for project management to make proper decisions and solutions.

Based on the outlined challenges of project knowledge management, in the following a promising technology-based approach is presented, which combines a RPA-based framework for knowledge controlling with a graph-based solution for knowledge mapping.

3 Robotic Process Automation for Project Knowledge Management

3.1 Robotic Process Automation

Robotic Process Automation (RPA) is understood as the automation of well-structured and rule-compliant processes which have been performed by human agents so far by means of software robots (Willcocks et al. 2005, pp. 5–6, Mendling et al. 2018, pp. 300–302, Allweyer 2016, pp. 1–3, IEEE 2017, p. 11). For that the software robot (or bot) imitates the behavior of the human agents, i.e. it enters data into or reads data from control elements of programs (e.g. entry masks), changes data, moves data between programs or starts programs (Allweyer 2016, p. 2, Czarnecki & Auth 2018, pp. 116–117).

The objective of RPA is the elimination or at least minimization of human interaction within a business process. Bots can handle processes much faster, in higher quantity and without changes in quality. With bots taking care of the repetitive and tedious tasks, humans are free to concentrate on the tasks that involve decision making or are of immediate use for the customer (Hofmann et al. 2019, p. 3, Mendling et al. 2018, p. 302, Smeets et al. 2019, p. 22, Willcocks et al. 2015, p. 6).

Bots are not bound to single systems; they can emulate users across different systems. By mimicking human behavior bots do not (necessarily) need application programming interfaces for system access. Thus, the existing systems remain unchanged. RPA simply creates a supplementary layer of technology above the existing IT landscape without any program or data integration (van der Aalst et al. 2018).

This aspect is the reason for the high expectations of a robotic process automation (Bingler 2019, Czarnecki & Auth 2018, p. 117): With only minimal changes to the existing IT landscape processes can be optimized and automated much faster than with the introduction of new software or the revision of existing systems and the time-consuming integration of all systems on an technical level. There is recognizable potential for process automation and for significant cost reduction (Smeets et al. 2019, pp. 22–23, Lacity et al. 2015).

The initial stage of RPA adoption comprises the automation of well-defined processes (Agostinelli et al. 2019). The next stage will see the combination of RPA with techniques of artificial intelligence (AI) to an "Intelligent (Process) Automation" (Berruti et al. 2017, Huang & Vasarhelyi 2019, p. 9, Bingler 2019, Bremmer 2019, Safar 2019). RPA bots are supposed to take over more unstructured processes and decision-making tasks and learn from human users and previous process executions (Mendling et al. 2018, p. 301, Czarnecki et al. 2019, pp. 799–801, Bremmer 2019).

3.2 Graph Database and Bot-based Solution for Project Knowledge Management

3.2.1 Parameterizable Bot Structures

Project teams that operate virtual and across organizational boundaries are subject to the need to work with a wide variety of application systems and to exchange data between them. Due to security-related and legal framework conditions, this can rarely be achieved via technical interfaces. As solutions available on the market show heterogeneity in terms of technology, functionality and usability and the short innovation cycles in the field of teamwork-relevant software, a desired solution for project management must necessarily be highly flexible and be able to interact with any software. This is not in the nature of API-based system communication but can be solved using the RPA approach.

In contrast to classic use cases of RPA or Workflow Management, in which the processes can be implemented in a stable and thus fixed manner, a useful application of RPA in the context of virtual teams is only effective through highly parameterizable bot structures that are based on a knowledge database.

In a bot-based approach, a team bot supports or replaces the previous human integrator, who was necessary for the control of team processes and who had the relevant, sometimes implicit, process knowledge. The latter is explicated in the bot-based approach and persisted in a corresponding database (specifically a graph database, GDB; see chapter 4).

The current survey (Kneisel, Werner & Tietz 2020) initially revealed the need to store information about team members, their roles, relevant information objects, their storage locations as well as distribution scenarios for information objects. Furthermore, the flexible storage of team rules, i.e. of explicit process knowledge, is needed. These requirements can be met using the bot-based solution described below (see figure 1).

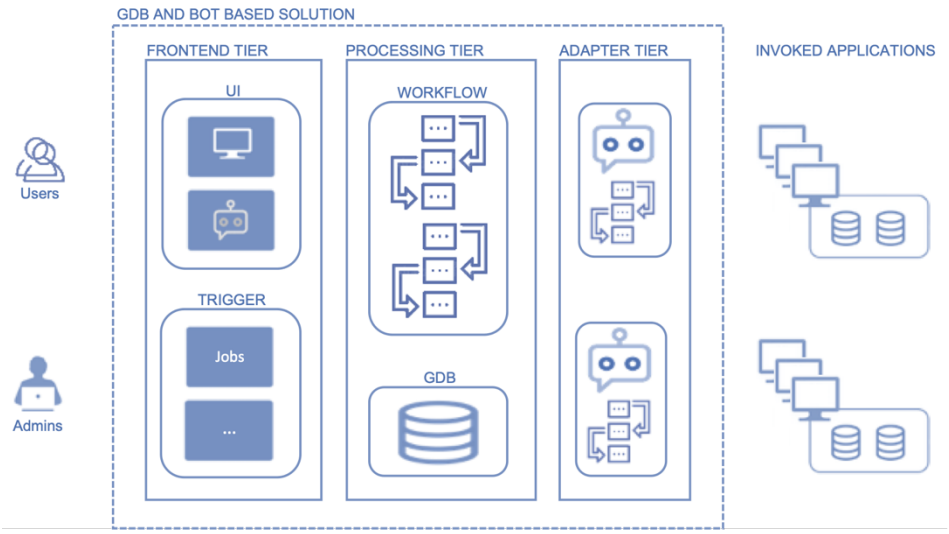

Figure 1: GDB and bot-based solution for project knowledge management.
Source: Authors

The core idea here is not to persist process-related information in a proprietary way within RPA systems, but rather to store it in a widely accessible knowledge database based on a graph database. The rules stored there can be directly linked to existing data objects in the database, and, at the same time, RPA systems from different suppliers can execute the process knowledge.

3.2.2 Frontend tier

End users communicate with the system via classic applications (personal information management software, messaging clients, VoIP software, etc.) or, for example, via chatbots. Events arising from this trigger the corresponding control workflow. Such events can also be raised by periodic jobs.

In this area there will be lots of add-ons using AI to optimize the work which has to be done in the front-end tier. A recent study depicts many areas for the application of AI to RPA (see Koch & Wildner 2020).

3.2.3 Process tier

On the process tier a central control workflow runs to select the correct response (i.e. a procedure with a collection of tasks) to a specific trigger. The control workflow executes the procedure tasks linked to the trigger based on information stored in a graph database.

However, the workflow is not a complete implementation of the process at design time, rather the relevant process information is obtained from a graph database.

The process tier has to handle aspects of system stability, integrity and scalability. The workflow and its information container are intended to be completely information agnostic to work in its intended generic implementation. Specific knowledge (as to how people of a team interact, etc.) is stored exclusively in the graph database.

3.2.4 Adapter tier

The control workflow as well as the actual interaction with target systems is realized via software bots using RPA technology. This ensures that changes to the IT landscapes in which the bot-based solution is applied are reduced to a minimum. However, if there is a continuous, simple and secure way to adress an API, the usage of this kind of connectivity should be preferred. If not available RPA will be the technology of choice.

Here, a target-system-specific implementation takes place at design time and the relevant execution parameters are transferred, which are obtained from the knowledge database through the control workflow, at runtime. At this point there has to be also deep knowledge about the information gathered in the workflow container.

Actually, the adapter tier looks quite similiar to normal RPA projects, only without the flexible structures we discuss in the paper. But the reusability of the elements will be much higher, if the concept proposed here is followed consistently.

4 Persistence Layer using Graph Database Technology

4.1 Graph Databases

The persistence of process knowledge must be implemented in such a way that, on the one hand, a flexible expansion of the data structures is possible, for example the arbitrary addition of entities, and on the other hand there must be the possibility of using e.g. AI, data mining or process mining technologies on this data. In this context, implementation is based on a graph database (GDB).

Graph databases are used primarily when connections between data objects are more important than the data itself. Compared to relational databases, a particular advantage is the improved representation and investigation of complex systems. The many different relations are represented in the form of graphs. Thus, they can also be visualized much more efficiently. The use of these databases has become particularly prevalent over the last decade. In principle, they complement other concepts, such as hierarchical or relational databases (Angles & Gutierrez, 2008).

Many graph databases provide tools for a graphical representation of the data. It enables visualizations that make it easier for people to recognize connections visually. In combination with process models, such as the robotic process automation, this opens up new possibilities for gaining knowledge.

With process models, it depends first of all on how much time is spent on individual stages. In addition, people play a role in robotics, since these tasks are designed for robots. Graph databases, in combination with semantic tools or artificial intelligence in general, allow to model knowledge in these approaches. In content-rich processes it is particularly important that documents and roles are semantically processed. In fact, the content rarely depends on quantitative values like in a normal database, but on the connections. Thus, we apply graph databases. Hereby, so-called edges and nodes play an important role (Jouili & Vansteenberghe, 2013).

If we now look at our processes, that we intend to automate using RPA, it is not primarily the absolute values that matter, but the connectivity. This enables us to answer questions such as the following: What is the shortest route that can be taken

when a user submits an error to the help desk, for example? If there are similar problems, we can identify these, by looking for specific clusters in corresponding visualizations. However, the images are not essentially required since graph database often come with a specific query language such as Cipher for Neo4J (Wood, 2012).

4.2 Design of the persistence layer

The meta model of the persistence layer differentiates master data – even transaction data if needed and not usefully stored in backend systems – as well as rules, e.g. approval limits and the actual process information. In the interests of greater reusability, standard tasks are first encapsulated and then reused in procedures. (see figure 2).

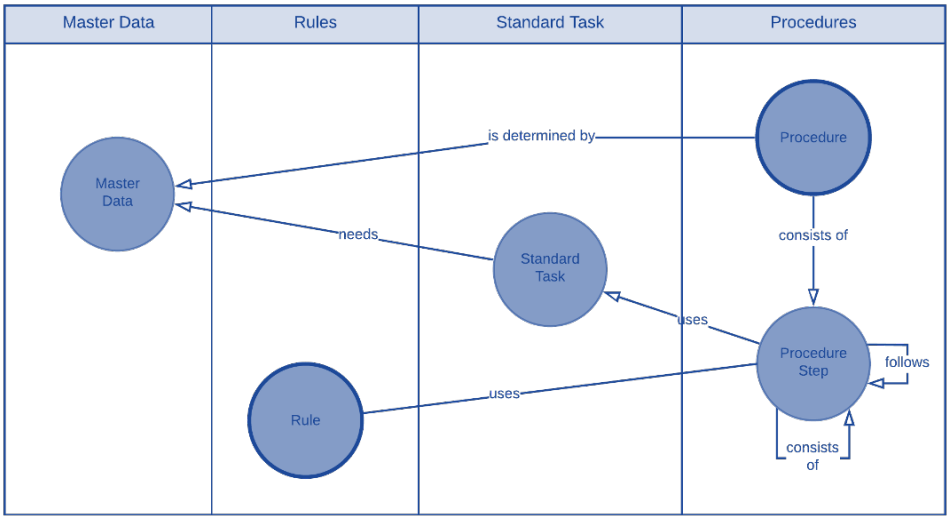

Figure 2: Data meta model
Source: Authors

The graph database contains data objects in the classical sense as well as process-related information, represented here by procedure steps and standard tasks. A procedure is then executed step by step by the Workflow Engine of the RPA system. Encapsulated in standard tasks, the relevant data objects are obtained for each

procedure step. It is also possible to access rules directly from Business Rules Frameworks. Figure 3 illustrates an example of such a persistence solution.

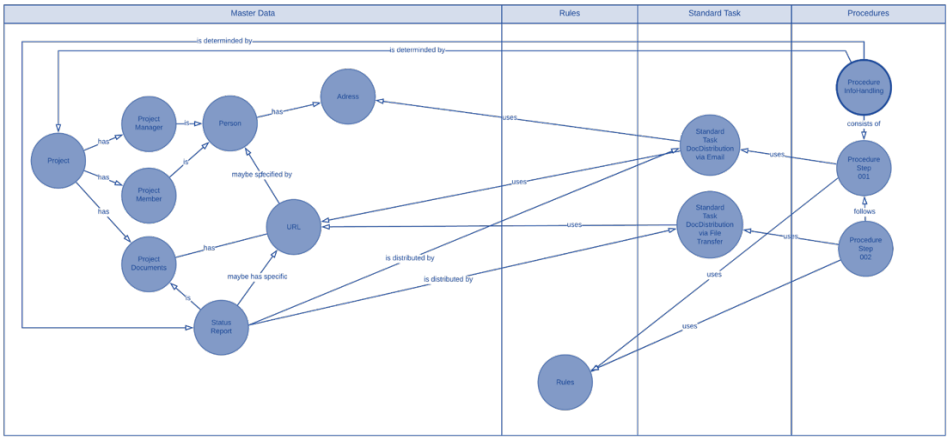

Figure 3: Modelling of master data, rules and procedures (example).
Source: Authors

5 Conclusion

This paper suggests an integrative approach to optimize knowledge management tasks in project management using modern technologies such as GDB and RPA. Where a high degree of flexibility and reusability can be recognized, it is provided by the separation of tiers and especially the persistence layer.

The explication of project knowledge can be supported in this way and, above all, methods of AI can be applied to the data and process information.

Further research in the project described here will first investigate the mapping process of the content in the graph database and link it to data objects. Furthermore, we plan to "find" optimum process paths by elucidating content relations machine learning. For this purpose, we plan to investigate a standardized process with and without graph databases/AI. Exemplary and specific processes from the project management environment, especially elements of the executing process group according to PMI (PMI, 2017), will be used to validate the procedure in practice.

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CROWDSOURCING THROUGH TWITTER FOR INNOVATION

HELEN CRIPPS[1], ABHAY KUMAR SINGH[2],
THOMAS MEJTOFT[3] & JARI SALO[4]

[1] Edith Cowan University, School of Business and Law, Perth, Australia, email: h.cripps@ecu.edu.au
[2] Macquarie University, Macquarie Business School, Sydney, Australia, email: abhay.singh@mq.edu.au
[3] Umeå University, Department of Applied Physics and Electronics, Umeå, Sweden, email: thomas.mejtoft@umu.se
[4] University of Helsinki, Faculty of Agriculture and Forestry, Helsinki, Finland, e-mail: jari.salo@helsinki.fi

Abstract This research investigates the role and use of Twitter in business markets and benefits of using open social media channels to crowd source information to support innovation and build relationship in the context of business-to-business (B2B) marketing. This study is based on a combination of methodologies, 52 face-to-face interviews across five countries are compared with a sample of their Tweets using Structural Topic Modelling (STM) which enabled triangulation between stated use of Twitter and respondent's actual Tweets. The research confirmed that individuals used Twitter as a source of information, ideas and innovation within their industry. Twitter enables the building of relevant business relationships through the exchange of new, expert and high quality information within like-minded communities in real time, between companies and their suppliers, customers and also their peers. This research highlights the business relationship building capacity of Twitter as it enables customer and peer conversations that eventually support the development of product and service innovations.

Keywords: social media, innovation, twitter, crowdsourcing, topic modelling.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.13
ISBN 978-961-286-362-3

1 Introduction

Social media has over the last 15 years gradually become a natural, and important, part of our everyday lives and today different social media channels are used in both professional and private matters. Social media is a "group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user generated content" (Kaplan and Haenlein, 2010, p. 61; Edosomwan, Kalangot Prakasan, Kouame, Watson and Seymour, 2011; Lashgari, Sutton-Brady, Solberg Søilen and Ulfvengren, 2018). Today there is a vast range of social media platforms stretching from content sharing sites (e.g. YouTube) to full social network sites (e.g. Facebook) (Kaplan and Haenlein, 2010, Withheld, 2017). The foundation of Web 2.0 lies in the collaboration (Berners-Lee, 1999), the interaction and the two-way exchange of information. These factors have been crucial for the success of social media as a dominant platform for communication and media exchange (Edosomwan, Kalangot Prakasan, Kouame, Watson and Seymour, 2011; Lacka and Chong, 2016). The two-way nature of internet based communication technologies, such as social media, makes them, not only, an effective and dynamic medium for business-to-consumer (B2C) exchanges (Leonardi, Huysman and Steinfield, 2013; Tarnovskaya and Biedenbach, 2018) but also for political and social activities. Furthermore, they also enable communication between dispersed and decentralised individuals and entities (Kaplan and Haenlein, 2010; Wang, Rod, Ji and Deng, 2017). Previous research on social media has indicated that businesses experience a positive effect when using social media. The two-way nature of social media makes these channels very effective when aiming for customer engagement since the channels give businesses the possibility to listen, respond and engage in discussion with customers (e.g. Jones, 2010; Tsimonis and Dimitriadis, 2014). However, the effect of social media on branding has been mentioned as complex and unpredictable (Tarnovskaya and Biedenbach, 2018) as in certain the uncontrollability of Twitter for businesses has been seen in the use of hashtags (Withheld, 2014). Regarding B2B exchange on social media, Cawsey and Rowley (2016) propose six components for an effective B2B social media strategy – monitoring the social media space, empowering employees, creating compelling content, stimulating e-WOM, and integrating social media marketing with other marketing more traditional strategies. However, the role of social media as a means for business-to-business communication and the differences in channel effectiveness has not as clearly been investigated (Lashgari, Sutton-Brady,

Solberg Søilen and Ulfvengren, 2018; Withheld, 2017; Hänninen and Karjaluoto, 2017). Previous research suggests that integrating social media into marketing communication is challenging and a social media presence is not effective as a standalone channel but rather should be supported by personalised communication (Hänninen and Karjaluoto, 2017; Valos, Habibi, Casidy, Driesener and Maplestone, 2016). Digitization of communication and the digitalization of society has allowed for a far more holistic impact on businesses than just around their communication and has changed how competitive advantage is gained and sustained (Brynjolfsson and McAfee, 2014; Wang, Rod, Ji and Deng, 2017). Today innovation, and especially open innovation, has been deemed important to cope with the increasing need for quick moves to gain and sustain competitive advantages in the increasingly aggressive and fast paced competitive environment (Chesbrough and Appleyard, 2007; Lee, Park, Yoon and Park, 2010). Simula and Ahola (2014) categorise four distinct crowdsourcing configurations - Internal crowdsourcing, Community crowdsourcing, Open crowdsourcing, and Crowdsourcing via a broker. In this model, community crowdsourcing and open crowdsourcing give scenarios with the focal firm both in (higher) control and with a high degree of openness of their crowdsourcing activities.

2 Crowdsourcing Innovation

One of the ways that companies have found to access knowledge to source innovations is by using social media, such as blogs, to collect innovative ideas from their users (Jussila, Kärkkäinen and Multasuo, 2015). This online exchange has the potential to generate increased "collaboration among the organisation employees and giving the organisation an image of a more 'open to critique and new ideas' kind of organisation" (Scupola and Westh Nicolajsen, 2013, p. 35) and, hence, support the foundations of open innovation. It is also important for companies to include social media in the dialogue with customers and in their marketing mix, as customer engagement through electronic word-of-mouth (eWOM) using Twitter enhances overall engagement and brand loyalty (Jones, 2010; Tsimonis and Dimitriadis, 2014). However, it is noted by Chesbrough (2011) that taking this "relationship" with customers to crowdsourcing comes with a caveat, that the community from which this wealth of ideas is obtained must be properly cared for and engaged, otherwise their willingness to participate will be destroyed. Social media can be utilised across

the stages of innovation from ideation to commercialisation providing creativity, expertise and collective intelligence and different social media channels serve different roles in the innovation process (Jussila, Kärkkäinen and Multasuo, 2015; Lashgari, Sutton-Brady, Solberg Søilen and Ulfvengren, 2018; Mount and Martinez, 2014). Compared to other social media, such as Facebook, Twitter enables the dissemination, feedback and ideation in real time for product development without the interference of algorithmic timeline distortions (Leek, Houghton and Canning, 2017; Mount and Martinez, 2014). The almost instantaneous exchange of information enabled by social media and the ability for this information to contribute to innovation was the impetus for the investigation of the role of the microblogging service Twitter as a possible source of innovation (Kubowicz Malhotra and Malhotra, 2016; Mount and Martinez, 2014). Researching identifying how companies use social media has risen in prominence during the last ten years (Lehtimäki et al. 2009; Withheld, 2017). However, Twitter use in industrial markets is more recent phenomenon with firms using Twitter to manage interactions with customers (Andzulis, Panagopoulos and Rapp, 2012). Companies from different industry sectors tend to use Twitter for different purposes (Xiong and MacKenzie, 2015). According to Swani, Brown and Milne (2014) marketers use Twitter to message differently between the industrial and consumer context. Furthermore, B2B companies tend to use more emotional than functional appeals in their tweets and avoided the "hard sell" (Swani, Brown and Milne, 2014). Leek Canning and Houghton (2016) show how the follower's response to the Twitter messages by utilizing the Task Media Fit Model. With a semiotic single case study Mehmet and Clarke (2016) provide a review of the meanings of specific online virtual conversations (Facebook, Twitter and website). The lack of research around the use of Twitter in the B2B context has led to this research investigating how Twitter is used by small and medium sized firms to support innovation within and between companies.

3 Methodology

3.1 Interviews

Though there is a considerable amount of academic research around text mining and data mining companies Twitter feed (He and Wang, 2016; Liu, Cao and He, 2011; Mehmet and Clarke, 2016; Swani, Brown and Milne, 2014), very little research has been published on the motivations for the use of Twitter in business relationships. The interviews sought to investigate the interviewees' behaviour on Twitter, including what activities they used it for, their motivations behind whom they chose to follow on Twitter and how they used it to grow business relationships and company profile. The interview data is from 52 interviews carried out from August to October 2015 across 5 European countries – Great Britain (12), Germany (11), Sweden (8), Finland (13) and Norway (8). The sample was based on individuals that used Twitter in their role in B2B marketing. While it is a convenience sample the behaviour was surprising similar across cultures and industries. Regarding the official role at the company, 40% were involved in a marketing role, 21% being a founder, 15% chief executive officer and 11% involved in IT related activities. Furthermore, 75% had worked for in their current role for five years or less. The organisations for which the interviewees worked ranged from consultancy or micro businesses employing less than 10 people to large multinational businesses employing over 2,500 people. Of the 52 companies 75% had 100 or less employees, and 57% had 25 or less employees and these were predominantly IT related start-ups.

3.2 Structural Topic Modelling

Text data sourced from social media and other electronic media is usually very large and has higher order dimension. Topic models are probabilistic statistical text mining algorithms for discovering the underlying meaningful text organisation of a document to uncover the main themes in an unstructured collection of text. Hoffman (2001), proposed one of the first such probabilistic topic modelling algorithms, which was then succeeded by Latent Direchlet Allocation (LDA) by Blei et al (2003). Blei et al. (2003), proposed LDA as an unsupervised approach that assumes a document comprises of multiple topics. Topics are defined as a distribution over a set vocabulary of terms (words). Topic modelling algorithm

assumes that a certain number of topics (k) are present in a collection of (n) documents in different proportions. Each term (word) originates from one of the topics, which is identified from the per-document distribution over topics. LDA defines a dirichlet distribution to identify these topics for each document. For the sake of brevity, the technical details of LDA are not mentioned here. The text mining analysis in this study used STM to search for possible topics in a sample of tweets posted by the interviewees. The STM method is particularly useful in this analysis as it allows for inclusion of metadata in the text corpus. This allows STM to model topical prevalence, specified as simple generalised linear model on a number of document-level covariates. The STM method has been gaining popularity in academic research to generate topics from various sources of data like, international newspapers, open ended interview responses, and online class forums as well as Twitter data (Lucas, Nielsen, Roberts, Stewart, Storer and Tingley, 2015; Reich, Tingley, Leder-Luis, Roberts and Stewart, 2015; Roberts, Stewart and Airoldi, 2016). The text corpus used for the topic modelling exercise consists of tweets posted by a group of interviewees from companies with less than 100 employees as companies are categorised as Small or Medium Scale Enterprises (SME)[1]. To investigate SMEs use of Twitter for innovation and crowdsourcing, the data set was divided into companies that used Twitter at least once a month for innovation and less than once a month, based on their responses during the interview. The final sample of 38 companies with 10 having reported using Twitter at least once a month for innovation and crowdsourcing and the rest 28 using it less than once a month. This binary classification for SMEs is used as the covariate in the STM analysis to check if the topic prevalence differs in these two SME classes. The tweet database included the most recent 500 tweets or less (depending on the number of available tweets) per user which were downloaded subsequent to the interviews being conducted. The data sample contains 15,054 multilingual tweets from 38 Twitter handles. As the tweets are posted in various languages (e.g., Finnish, German, Swedish), they are first translated to English using the Google Translate API (via Google Sheets)[2] for the analysis. Although it wasn't possible to double-check all the translations, translations from familiar languages, e.g. Swedish, Finnish, German etc, were randomly checked. For the topic modelling exercise, the dataset is pre-processed to remove non-

[1] This definition is not absolute here, it can vary in different countries based on their categorisation. This was use this for convenience and to account for small companies.

[2] There are some studies which support the use of Google Translate API or similar machine translation tools for text mining (Lucas et. al., 2015 and de Vries, Schoonvelde & Schumacher, 2018).

character text, html code, and common English stop words. The dataset is further stemmed to reduce words to their root form before conducting the analysis. Additionally, the words appearing in less than 10 tweets are dropped from the dataset, which adjusts the vocabulary and the number of tweets resulting in 14704 tweets and 1768 words in the vocabulary.

4. Results and Discussion

4.1 Results from the Interviews

While 85% of interviewees checked their Twitter account daily, only 46% of interviewees tweeted daily. The survey found that Twitter as a channel was primarily used as a communication and information gathering platform by individuals (Hänninen and Karjaluoto, 2017). The interviewees did not consider they had to use Twitter to compete in their industry, and generally were one of the few Twitter uses in their company (Keinänen and Kuivalainen, 2015). When asked what factors the interviewees considered when deciding to follow someone on Twitter (Table 1) being knowledgeable and influential were considered to be important characteristics of those that the interviewees chose to follow (Hänninen and Karjaluoto, 2017).

Table 1: Characteristics Important in the Decision to Follow

How important are the following in your decision to follow someone on Twitter	**Mean**
Their level of authenticity	5.86
Quality of Information they share	5.84
Their relevance to your business	5.67
Their expert knowledge	5.33
Their level of integrity	5.29
Their level of influence in my industry	4.92

Interviewees cited other factors in their decision to follow someone, and these included "level of innovative thought", "new inspiration and ideas" and "learn from others, reciprocation of interests". The authenticity and integrity of the accounts the respondent followed was considered important, as the tweets of the accounts that the interviewees followed appear on their Twitter feed (Valos, Habibi, Casidy,

Driesener and Maplestone, 2016). If the content was inappropriate this reflected poorly on the account owner and company. Similarly, the main reasons the interviewees unfollowed someone on Twitter was the thought that the information provided was no longer of interest, trustworthy or of sufficient quality. The benefits of using Twitter (Table 2) mentioned by the interviewees included the ability to build trust, provided quality information distribution and exchange and linking or collaborating with others in the industry.

Table 2: Importance of the benefits of Twitter

Rate the importance of these possible benefits of Twitter	**Mean**
Builds your company's brand	6.06
Quick way to distribute information	6.04
Builds trust with others	5.87
Put you at the "Top of mind" for your customers	5.56
Linking to others in the industry	5.54
Gathering business intelligence	5.02

These finding is in line with the commitment-trust theory of Morgan and Hunt (1994) and similar to Quinton and Wilson (2016) findings with LinkedIn. When asked to identify the risks of using Twitter, issues such as loss of control of the conversation, being misunderstood and the negativity of others were raised (Mehmet and Clarke, 2016; Valos, Habibi, Casidy, Driesener and Maplestone, 2016). In light of this, it was surprising that when asked if the interviewees had social media guidelines, only 48% said they had a formal written policy, 17% had an informal policy, and 35% said they had no policy at all. This finding is consistent with Iankova, Davies, Archer-Brown, Marder and Yau (2018) who found a lack of formal strategies in B2B firms. The interviewees were asked to describe the types of guidelines they applied when using Twitter; common responses included being conversational, informative, quality content and the use of common sense when posting information. Of their experience of using Twitter 92% of the interviewees agreed that "using Twitter enhances your creditability" and 75% agreed that using Twitter makes it easier to gather information, which is in line with the concept of social enhancement raised by Yavuz and Toker (2014) in the B2C context. The benefits of Twitter included; "quick way to distribute information", it was beneficial when "gathering business intelligence", "create a community - our company started with a tweet to the world", "crowd sourced way of finding interesting stuff" and

"Identifying trends, what's next". The building of personal credibility through social media is usually associated with personal branding rather than the B2B context (Khedher, 2014; Ngai, Tao and Moon, 2015). These results indicate the use of Twitter as a source of credible knowledge, information and innovative ideas and are consistent with the previous research of authors such as Kaplan and Haenlein (2010) and Kietzmann, Hermkens, McCarthy and Silvestre (2011). The instantaneousness of the Twitter feed as conduit for awareness and information exchange supports the findings of Leek, Houghton and Canning (2017), Mount and Martinez (2014), and Park, Lim and Park (2015). These results were the impetus for the investigation of the content of the interviewees' Twitter feeds.

4.3.2 Results from STM Analysis

The topic selection based on topic semantic coherence and exclusivity indicated 20 as the appropriate number of topics for analysing the tweet data. The 20 topics derived from the STM analysis of the Twitter streams are displayed in Figure 1, which provides a list of top topics according to their expected proportion in the tweets posted by the interviewees.

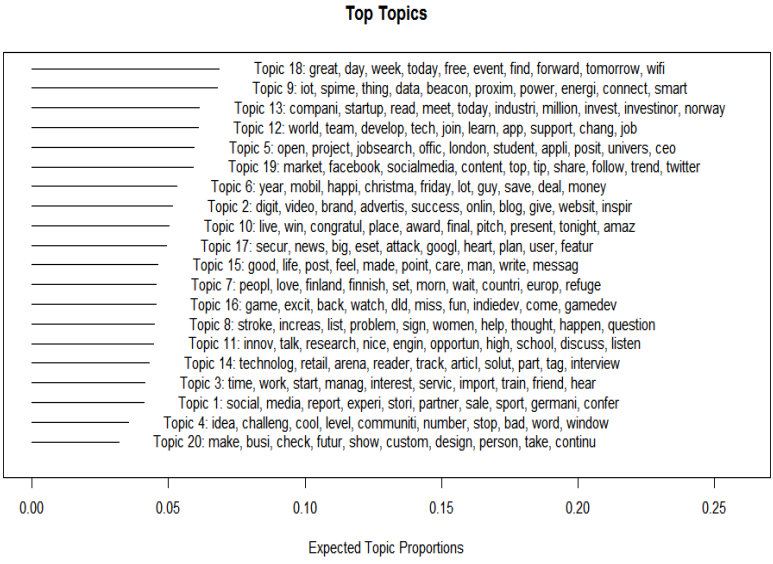

Figure 1: Topics sorted according to their expected occurrence

The topics generated in the analysis are formed of words associated with them. Figure 1 shows top 10 words (according to their probability of occurrence) per topic, which are used to identify the generalised topics. For example, Topic 18 that has the highest proportion in the data has words like "day", "week" and "today" which are associated with describing daily activities or used for posting updates on Twitter. These words identified for each topic can also be linked back to the tweets (documents). On closer inspection of these topics, it is observed that some of the topics as generated by STM have common words. For example, Topic 1 and Topic 19 have words like, "social", "media", "socialmedia". This indicates that there can be some correlation between these topics making them related to each other and hence a further analysis of this likely correlation is conducted to group the topics together as illustrated in Table 3.

Table 3: Labelled topics with top 10 words in each

Group	Assigned Label	Topic	word 1	word 2	word 3	word 4	word 5	word 6	word 7	word 8	word 9	word 10
1	General social media, Online promotion and social media marketing	1	social	media	report	experi	stori	partner	sale	sport	germani	confer
		2	digit	video	brand	advertis	success	onlin	blog	give	websit	inspir
		3	time	work	start	manag	interest	servic	import	train	friend	hear
		6	year	mobil	happi	christma	friday	lot	guy	save	deal	money
		12	world	team	develop	tech	join	learn	app	support	chang	job
		15	good	life	post	feel	made	point	care	man	write	messag
		18	great	day	week	today	free	event	find	forward	tomorrow	wifi
		19	market	facebook	socialmedia	content	top	tip	share	follow	trend	twitter
		20	make	busi	check	futur	show	custom	design	person	take	continu
2	Social well being (Health or Social security)	8	stroke	increas	list	problem	sign	women	help	thought	happen	question
		17	secur	news	big	eset	attack	googl	heart	plan	user	featur
3	Open Innovation & Learning	5	open	project	jobsearch	offic	london	student	appli	posit	univers	ceo
		11	innov	talk	research	nice	engin	opportun	high	school	discuss	listen
4	New idea & promotion	4	idea	challeng	cool	level	communiti	number	stop	bad	word	window
5	About people and society	7	peopl	love	finland	finnish	set	morn	wait	countri	europ	refuge
6	Internet of things and Big Data	9	iot	spime	thing	data	beacon	proxim	power	energi	connect	smart
7	Online Promotion/Announcements	10	live	win	congratul	place	award	final	pitch	present	tonight	amaz
8	About start-ups and investment in the region	13	compani	startup	read	meet	today	industri	million	invest	investinor	norway
9	Retail Technology	14	technolog	retail	arena	reader	track	articl	solut	part	tag	interview
10	Game Development	16	game	excit	back	watch	dld	miss	fun	indiedev	come	gamedev

The mean difference for all 20 topics were compared for two different groups (1) SMEs reporting the use of twitter for innovation activities such as crowdsourcing of ideas or information less than once a month and (2) SMEs that use Twitter for the same at least once a month (SME_Inov). This further analysis based on the SME factors shows that various topics, including Topic 9 (IoT and Big Data) and Topic 14 (Technology in Retail) occur more frequently among these interviewees in the second category of interviewees who use Twitter for crowdsourcing, innovation and gathering ideas. These are insightful results as Topic 4, Topic 7 and Topic 10 about new ideas, promotion and society are also more frequently used by the SMEs using Twitter for innovation. Figure 2 shows the topics that are more associated with each

group. Topic 9 and Topic- 14 are clearly in the second group. These results indicate that the SMEs in our sample are in fact utilising Twitter as a social media channel for open innovation and crowdsourcing, information and feedback. Overall, the topics related to today's advancements in technology, including, IoT, big data, the retail sector and new ideas are among the topics more frequently talked about by SMEs identifying themselves as the ones using Twitter for innovation and crowdsourcing at least once a month.

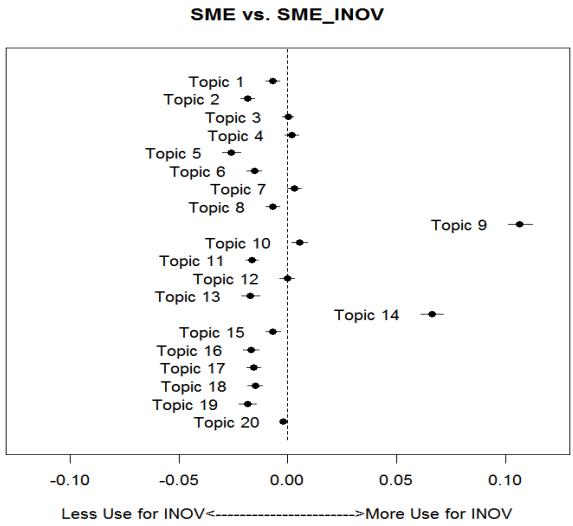

Figure 2: Topical Prevalence Contrast between interviewees reporting use of Twitter for Innovation at least once a month and Total Population

The STM analysis provides some insightful results not only in terms of the words generated for different topics but also the different topical prevalence depending on the purpose and frequency of use of Twitter. Overall, it can be concluded that the results generated using modern text mining method of STM verify the results from the interviews. The analysis successfully identifies words utilised by Twitter users in our sample, which they frequently use to discuss innovation around technological advancements in the European region. The identified topics also show how the technologically advanced fields of IoT and big data are popular among SMEs looking for innovation. Investigating other covariates like industry sector can develop this initial analysis further or the number of followers to create a lexicon

with frequently used words around innovation, crowdsourcing, ideas gathering, and social media marketing.

5 Conclusion

The aim of this research was to investigate how Twitter is used as a medium for innovation by small and medium sized firms and how Twitter is being used to support innovation within and between companies. The major theoretical finding is that the stated use of Twitter in the interviews and actually tweets of the interviewees supported the use of Twitter as a social media channel with the ability to provide companies with a powerful tool to access information and ideas from which to develop innovations and sustain competitiveness (Estellés-Arolas and González-Ladrón-de-Guevara, 2012). Innovation is central to competitive advantage, both for corporations and institutions; and previous research has shown that social media channels have a role to play in the development and support of this innovation (Chesbrough and Appleyard, 2007; Lee, Park, Yoon and Park, 2010). The results strengthen previous findings that the social media channels such as Twitter can be used as a source of information, ideas and innovation (Leek, Houghton and Canning 2017; Mount and Martinez, 2014). The research highlights the value of Twitter as a platform for the exchange of new, expert and high quality information within like-minded communities on topics such as Internet-of-Things (IoT), eHealth, software development and the technology based start-up. The high speed and un-curated exchange of information enabled by Twitter seems to be closely aligned to the organic culture surrounding technology based start-ups. The immediate nature of the Twitter feed enables collaboration in real time between companies and their suppliers, customers and also peers (Edosomwan, Kalangot Prakasan, Kouame, Watson and Seymour, 2011). The importance of peer-to-peer discussion or communications and access to experts and thought leaders for B2B companies was evident from the interview findings (Leonardi, Huysman and Steinfield, 2013). This interaction was also seen as a means of improving personal credibility in an area more closely associated with B2C interactions (Khedher, 2014; Ngai, Tao and Moon, 2015; Tarnovskaya and Biedenbach, 2018). The research illustrated how Twitter could be used to source and the exchange of high quality, relevant and current information as part of the innovation process. The research found that the conversational and egalitarian nature of Twitter enabled interviewees to use it as a channel for customer and peer conversations that supported the development of

product and service innovations. Twitter is a tool that allowed the interviewees to interact with a diverse network that may not be open to them in the offline world and should not be used as a direct marketing channel for products and services. Instead the research found that Twitter was effective for promoting events, recognition of others in the network, for building the brand of individuals and companies by informing and engaging customers and peers in their network on wider topics (Swani, Brown and Milne, 2014; Hänninen and Karjaluoto, 2017). Finally, although the companies interviewed regularly used Twitter for innovation, very few of the companies interviewed had any formal framework for the measurement of return on investment for their use of Twitter. They considered it to be "worthwhile and important to be there" but lacked clearly defined objectives for their participation or the expenditure of time and resources (Iankova, Davies, Archer-Brown, Marder and Yau, 2018). If Twitter is to be used for crowdsourcing, innovation and industry insights, it is suggested that companies create guidelines that facilitate the care and engagement of their Twitter community to ensure their on-going participation (Chesbrough, 2011). The Topic Models created as part of the research provide a lexicon for frequently used words around innovation, crowdsourcing, ideas gathering and social media marketing that could be used to source and engage in conversations around these topics.

Further research needs to be conducted into the application of text analysis methods like sentiment analysis and STM, along with social network analysis can also be implemented to generate further insights to analyse the impact of online platforms in the B2B context. The convivence sample need to be followed up with more extensive survey research.

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ETHICAL GOVERNANCE OF EGOVERNMENT ECOSYSTEMS

JANI KOSKINEN[1], MIKKO VERMANEN[1],
MINNA M. RANTANEN[1] & SAMI HYRYNSALMI[1]

[1] University of Turku, Information Systems Science, Turku, Finland, e-mail: jasiko@utu.fi, minna.m.rantanen@utu.fi, mjverm@utu.fi

Abstract Digitisation of governmental services has become a common approach to make governing more effective and efficient. The eGovernment services can be built on top of a variety of information systems and supplied to and between individuals and organisations on both national and international levels. This results in a complex organisational and socio-technical ecosystem containing a vast amount of variables affecting the privacy and safety of citizens.

Thus, achieving these better societies relies strongly on common trust between the citizens and governments. This calls for 'governance of governance', which can prove to be difficult to manage. Even in this challenging environment, it is crucial that ethical principles are applied to the highest possible degree. Yet, in current research, the citizens are often neglected.

In order to develop a better society for all, we should objectively consider the ends and means of eGovernment. In this paper, we study the relation of the citizens and eGovernment systems from an ethical perspective in order to represent which ethical considerations should be made if one wishes to truly aim for a better society.

Keywords: eGovernment, governance, ecosystems, ethics, discourse ethics.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.14
ISBN 978-961-286-362-3

1 Introduction

eGovernment is a shorter form of electronical government, which refers to the use of information and communication technology (ICT) tools and applications to enhance government (Al-Hujran et al., 2015; Panagiotopoulos et al., 2012). In this paper, we consider these interconnected information systems as eGovernment ecosystems — *complex socio-technical system incorporating citizens, organisations, companies as well as governmental agencies, which use electronic platforms to create and distribute value to its participants* (Rantanen et al., 2019). Thus, we see eGovernment ecosystems as collections of governmental institutions, organisations, and citizens connected through applications of ICT.

Efficiency seems to be the common motivation behind all eGovernment services. However, also better services for citizens, improved processes and governance, transparency and deliberation, creation of public value, and empowerment of citizens are often mentioned as motivators and benefits of eGovernment (Grönlund and Horan, 2005; Al-Hujran et al., 2015; Venkatesh et al., 2005). Thus, the eGovernment ecosystem is seen as a way to serve the needs of citizens, but also as a tool for a more efficient and better way to govern. Achieving these goals and benefits requires citizen engagement and the vast adoption of a variety of eGovernment services. But it seems to be a lasting problem, since adoption rates are staying fairly low (Al-Hujran et al.,2015; Venkatesh et al., 2005).

Still, the majority of eGovernment research focuses on positive aspects from the managerial perspective (Madsen et al., 2014; Andersen et al., 2010). In addition, there is only a limited amount of research about practical research about actual implementation of eGovernment and how to measure those (Twizeyimana and Andersson, 2019). This is problematic since it has become apparent, that the impacts are not always as positive as assumed, the role of the citizens is fundamental but yet underestimated and the impacts of these systems are going to affect our societies for a long time. Since these systems are going to have a great impact on our society, we should be aware of the unintended and unwanted outcomes and aim to design eGovernment that actually serves the citizens as well as a government without doing harm (Rantanen and Koskinen, 2019).

To balance and to justify the values and needs of the citizens and government, we should assess eGovernment ecosystems from the perspective of ethics. In other words, we should strive to develop more ethically justified eGovernment ecosystems. Since there has been very little research on ethical aspects of eGovernment - let alone from the perspective of eGovernment ecosystems - our aim is to clarify some ethical implications that should be taken into account. Thus, in this paper, we present some ethical considerations about eGovernment ecosystems by means of philosophical argumentation in context of eHealth and eGovernment as whole.

Our research question is: "Which ethical considerations at least should be taken into account to make an ethically justified eGovernment ecosystem?"

The rest of the paper is structured as follows: Section II clarifies the theoretical background of eGovernment ecosystems and need for ethical approach. Section III presents rational behind philosophical argumentation as a methodology and Section IV introduces the ethical basis of our analysis. Ethical considerations that should be taken into account so that we could reach an ethically justified eGovernment ecosystem are discussed in Section V. Finally, we conclude in section VI.

2 Background

Briefly explained, eGovernment refers to the use of information and communication technology (ICT) tools and applications to enhance government (Al-Hujran et al., 2015; Panagiotopoulos et al., 2012). Some of the expected practical benefits of eGovernment are added efficiency, better citizen services and improved democratic processes (Grönlund and Horan, 2005), as well as deeper transparency and enhanced interaction between citizens and governments (Welch et al., 2005). Overall, the eGovernment forms a complex socio-technical ecosystem involving a variety of stakeholders.

Before providing a more defined description of eGovernment, it is important to acknowledge that although the term is often used interchangeably with the term eGovernance, there are some significant differences between them. Calista and Melitski (2007) describe the terms as separate, yet complementary: eGovernment, they define, provides "governmental services electronically, usually over the Web, to

reduce the physical character of customer transactions by recreating them virtually" whereas "e-governance envisions employing the Web and Internet to overhaul how the state conducts its democratic dealings by using networked interactions with citizens to foster transparency and participation" (Calista and Melitski, 2007). Thus, we suggest that eGovernment should be considered as a system of digitised services for citizens, whereas eGovernance is a more comprehensive set of measurements, whose purpose is to govern democracy employing information and communication technology.

The eGovernment research often focuses on technical solutions and is rather technologically deterministic (Calista and Melitski, 2007; Madsen et al., 2014). This means, that the research does not acknowledge that implementing technology can have unintended consequences because of the ways that people interact with it, or that the features themselves cannot fulfil the expectations of citizens, thus failing to reach their intended goals (Welch et al., 2005). As an example when an information system is implemented, people can alter from the intended way of use, since the new technical system affects their way of doing something. Thus, a technical system affects the social system and vice versa. To understand eGovernment as a whole, we must move away from technological determinism and towards a more holistic view.

More holistic view can be taken through an ecosystem perspective, where the goal of added efficiency does not over- shadow the related ethical and societal implications, by defining data economy ecosystems as "*complex socio-technical system incorporating citizens, organizations, companies as well as governmental agencies, which uses electronic platforms to create and distribute value to its participants*." (Rantanen et al., 2019).

The describing term of an ecosystem has been used in a multitude of ways in the fields studying technology. Research has been done about software ecosystems (Bosch, 2009), information systems ecosystems (McKelvey et al., 2016) and ICT ecosystems (Smith and Elder, 2010) just to mention a few. General understanding of digital ecosystems depends on the field and their chosen focus.

In this paper, we are using the term ecosystem as a metaphor for a complex and open socio-technical system that is distributed, adaptive, with properties of self-organisation, scalability, and sustainability inspired from natural ecosystems (Briscoe, 2009). A central piece of an ecosystem is formed by the involved individual

stakeholders, whose role we aim to emphasise by questioning the previously addressed deterministic approach.

This said we encourage accommodating the eGovernment services and the underlying processes with the personal rights and needs of citizens through a more socially aware approach. Our view is that the eGovernment ecosystem is a socio-technical system orchestrated by the government, which also includes citizens and other user groups such as companies and their representatives both as users and as vendors. Hence, besides offering digital services, an integral characteristic of eGovernment is improving the interaction between citizens and governments and providing individuals with an opportunity to express their opinions towards the government. (Muir and Oppenheim, 2002)

Although the roles are quite similar as in the software ecosystems, there are still some differences. The role of citizens cannot be stated to be similar to customers, although the relationship with the government and citizens is often described as such (King, 2007). Furthermore, the literature suggests that the attitudes and trust towards eGovernment can vary based on a multiplicity of personal variables, such as age, gender and ethnicity (Tolbert and Mossberger, 2006), which emphasises the importance of acknowledging the social factors. Since our view relies strongly on the socio-technical paradigm most often used in the organisational setup, we should also clarify that we cannot treat citizens as employees either.

It must be also understood, that eGovernment ecosystems are not all about digitisation of the work of governmental employees. Although, currently eGovernment activities seem to be about digitisation of services, there is a visible thrive to make more technological innovations that could make governments even more efficient. For instance in Finland digitisation of public healthcare has already moved from digitisation of professional work to developing digitised services. The next step seems to be further utilisation of citizens' capabilities and possibilities to use technology as a preventive measurement in healthcare by means of personal health records. The idea is that these systems could replace the need of professional healthcare services in less serious medical situations. Despite promised benefits for citizens, such as empowerment, adoption rates of these governmental applications have been low. However, it is important to take into consideration that, concerning eGovernment in general, both positive and negative preconceptions have been

found to affect the eGovernment adoption rates, where the citizens that already trust their local government are more likely to be satisfied with eGovernment and vice versa (Welch et al., 2005).

Obviously, from the citizens' perspective using these kinds of applications would mean more responsibilities as well as time invested in using the system. Thus, the pervasiveness of eGovernment applications is growing. Changes in the technical side of the eGovernment ecosystem will also affect how our societies work and are. Despite this, there has still been very little interest in the societal and ethical implications of the whole eGovernment ecosystem from a critical perspective. Without making these considerations we could end up in a situation where our eGovernment ecosystem is ethically unjust and implications are not desirable. Understanding the unique nature of citizens and government in an eGovernment imperative, if we wish to examine it from an ethical perspective.

3 Methodology

It is reasonable to question the choice of a philosophical approach rather than some more commonly used empirical research methodologies for this analysis. Why not try to obtain empirical information about what people are actually thinking or experiencing rather than making philosophical - and often troublesome - claims? However, before answering this question, we must understand the position of interpretative research within the information systems (IS) research field as well as the position of philosophy within interpretative research (and we want to bring this also to the field of Ecosystems). As Stahl (2014) stated, the interpretative approach has long been accepted as an important research approach within the field of IS. It could even be said to be the dominant approach nowadays. Maybe the most influential paper that led to this widespread acceptance is Walsham's (1995) ground-breaking article about interpretive case studies within IS research. However, two decades later, Stahl (2014) criticised the domination of the empirical approach in interpretative research over other approaches such as philosophical argumentation. Stahl showed that the philosophical roots of interpretative research do not offer sound justification for the status of the empirical approach since interpretative research is based on personal perceptions (second-order perceptions) of empirical data (first-order perceptions).

As the combination of phenomenology and hermeneutics constitutes the philosophical basis of interpretative research, empirical research is not always required, even though it can be used and is justified in many cases. It is worth noting that interpretative research does not allege to lead towards truth claims in the same way that positivistic research does. Rather, it attempts to reconstruct other people's constructions. Therefore, it is reasonable to question why this particular empirical construction is preferred over alternative constructions (Stahl, 2014).

One possible reason for this preference is the lack of straightforwardness and validity on the part of interpretative research; hence, validity is pursued with rigour, principally via empirical methodologies. Stahl (2014) claimed that his article supports a richer and more enlightening landscape of interpretative research by pointing out how philosophy represents a valid interpretive research method. In his reply to Stahl, Walsham (2014) agreed with this aim of enriching research, although he did not accept some of Stahl's criticism. In any case, philosophical argumentation is used as an interpretative research method in this paper rather than the empirical interpretative research. By means of this choice, the present article provides an alternative and rich viewpoint for researching ecosystems using philosophical argumentation instead of other dominant approaches of the field.

4 Ethical Basis

A social contract is a theoretical approach that justifies states' power over individuals. It is based on the assumption of a social contract between the people and the state that grants the state rights that individuals deliberately give up, such as taxation, limitation of some liberties by legislation, use of force, etc. The idea is that by social contract we can have (or at least aim to) a just and secure society for all, instead of having a situation where the law of the strongest is the only law. However, both Locke (1690) and Rawls (2009) (and countless of other philosophers) underline the freedom of people, the issue that is needed to ensure that we are not falling under a depression of masses either but have ethically justified government.

To clarify what ethically justified actually means we must first understand what is ethics in the context of eGovernment. We begin the description of our "approach" with a collection of Moor's (1985) observations about what computer ethics is. First, it is the analysis of the nature and social impact of information technology — here governmental information systems — to identify justified policies for the ethical use of information technology. Secondly, Moor (1985) notes the importance of general ethics for computer ethics, since it provides categories and procedures of what is ethically relevant and thus we are using this as our ethical position. Thus, we are analysing the governmental ecosystem from three main philosophical views: consequentialism (focus on the outcome of actions), deontology (focus on Intention), and virtue ethics (focuses the virtues that are seen as ethical ones). These main philosophical approaches are commonly used when evaluating ethicality healthcare (Armstrong, 2006; Aita and Richer, 2005) but we are lacking the use of ethics in eGovernment apart from some exceptions (Roman, 2015). Next, we will briefly go through these three branches of ethics.

A. Consequentialism

Consequentialism is the ethical approach where the eval- uation of the ethicality of actions is based on what kind of outcome of the action will provide. Utilitarianism (the classical consequentialist theory) is simplified the evaluation of different action possibilities by outcome utilities of those alternatives. The term utility refers to "the good" that is evaluated and it can be different in a different context. There are hedonic utilities such as pleasure, happiness, etc.

B. Deontology

Deontology is a branch of ethics where ethicality of action is based on action itself, not on the consequences it produces. This means that the focus is on the intention of action, not in the outcome of an action. Here we are focusing on Kantian Deontology as it is regarded to be the central theory for all deontological theories (Alexander and Moore, 2016). Kantian deontology (central theory in deontology) is based on the rational agents (read human actor here) that has the autonomy to make decisions. This is a necessary but not sufficient basis for ethicality as an actor that not has autonomy cannot make decisions and thus actor cannot use their free will to act as they decide. Thus, to have people to be ethical, they have to have a possibility to be unethical. For evaluating ethicality of action Kant presented the Categorical Imperative that set demands that ethical rules should be universal, rule

must be followed voluntarily and we should always respect humans like Kant (1785) stated: ”Act in such a way that you treat humanity, whether in your own person or in the person of any other, never merely as a means to an end, but always at the same time as an end.”

C. Virtue ethics

Virtue ethics is an approach in normative ethics which can be defined as the one that emphasises the virtues and moral character, whereas deontology emphasises duties and rules or consequentialism that emphasises the outcome of actions. Ideally, seeking the virtues and development of one's own character are under constant development. The idea is that if a person is focusing on cultivating their own character and seeks a virtuous life, it will follow up with (more) ethical life. However, the focus is not on rules (intention) like ”do not lie” or consequences that may follow after lying. Instead, virtue would be honesty that one seeks and aims to achieve in ones' life.

5 Ethical Considerations

In our brief evaluation of ethicality of eGovernment we focus on first on case of eHealth as one example from perceptive of three main ethical brands: deontology, consequentialism and virtue ethics. After that, we focus on eGovernment as whole phenomenon and show considerations that should be made to avoid pitfalls and gain more ethically justified rationales behind eGovernment.

A. Case of eHealth

Ethically, the overall aim of using eHealth is to make healthcare more efficient, help patients by supporting self-care, empower the patient etc. Thus deontological perspective the use of eHealth in many cases is ethical as the intention is good. From the duty/rule perspective of deontology, there still is a need for development as we still lack the needed rules that would ensure the ethicality of eHealth (Rantanen et al., 2018).

However, from the consequentialist perspective, the situation is not so straightforward. Even technology has made modern healthcare possible by giving modern tools and systems the there is a dark side as well. In many cases, the real outcome of eHealth is lacking and the use of eHealth is driven by expectations rather than evidence. Likewise, the discourse about evidence is lacking and the field misses the needed comprehensive evaluation of eHealth interventions to advance the successful implementation of eHealth at the long-time period (Enam et al., 2018). Reliable evidence generated through a comprehensive evaluation of eHealth interventions may accelerate the growth of eHealth for long-term successful implementation and help to experience eHealth benefits in an enhanced way (Enam et al., 2018).

From a virtue perspective, the eHealth sets challenges for healthcare professionals. As an example, electronic health records have changed the work on nurses toward a more data-oriented direction where risk is to emphasise the technology and thus taking time form facing the patient and thus distracting the empathetic interaction (Robichaux et al., 2019) — issue that should be given special focus to protect the virtuous behaviour of healthcare professionals. Form positive side the eHealth has made possible for the patient to be more informed and have more possibilities to rule their patient information" — increased autonomy instead of being merely a passive and uninformed object. We see that this is a needed part for individual who wants to develop their characters in the health context.

B. Demands for eGovernment

The main intention that is commonly announced when justified development or deployment of eGovernment systems is to improve services by digitalisation which from the deontological point is a valid argument. However, this efficiency- based approach has commonly other rationales behind it. The cost efficiency is the most likely the main rationale which itself is also a justified reason. However, in many cases cost- effectiveness rationale comes up with also other changes: limitations of service for some groups, too simplified way of seeing those governmental services or unclear roles and responsibilities, likewise shifts duties from officials to citizen (Lee and Porumbescu, 2019; Anthopoulos et al., 2016; Gil-Garcia et al., 2019). Those outcomes are problematic — especially if those are known beforehand — and thus lack the clear and rational justification form the perspective of consequentialism and also from the deontological position. Especially if this efficiency is advertised but

the real focus is on the other rationales it is clearly unethical as the intention is the misleading public discourse and politics. Likewise, society is also about other intentions than efficiency such as freedom, equality, security, etc.

From the perspective of consequentialism, the outcome of an action is what makes action ethically justified. Thus, decisions of the authorities' can be justified if implementing an eGovernment system will add outcome as a whole even some issues could be lessening some good outcomes. This kind of approach is tempting from the perspective of authorities especially if their worldview is technologically deterministic or business-oriented and lacks the views from the practical level of government (Buffat, 2015). However, these kinds of worldviews in the context of government can foster a paternalistic approach and those are dangerous for a democratic society. This approach does not support the autonomy of citizens and thus sees citizens as incapable to consider what is best for them leads towards technocracy. Thus pure consequentialist approach has limitations that deontology and virtue ethical perspective reveal. Nevertheless, the outcomes or consequences of eGovernment is one part of the ethical analysis that should be used, even it has its blind spot like the other two approaches as well.

Virtue ethics can be simplified stated to be an ethical theory where the development of character and virtuous actions are an issue that creates a good society — virtuous person comes up with actions that contribute to the good society. By Aristotle, virtues are thus good attributes such as truthfulness, liberality, courage, friendliness, etc (Ameriks and Clarke, 2000). As virtues are part of character the moving government towards automated systems there lies the risk that we remove responsibility from public officials and lessening human encounters between state and citizens. This is problematic as taking responsibility and humane treatment of people are characteristics that we see to be virtuous instead of avoidance of responsibility or automatisation of human contact in society. This is just an example of risks that can be made without taking account of the virtue approach wherein the centre is the human being — either citizen or official and their development as persons.

C. Discourse ethics to rule them all

Discourse ethics offers the solution to this problem of combining all of the aforementioned ethical theories. There exist a consensus amongst normative theorist of cultural pluralist that dialogue is the key for securing just relation between different groups. (James, 2003) Discourse ethics is an applicable tool to bring different views under constructive debate. It is a way to reveal the strategic logic behind group conflicts presented above and thus helps discourse toward a more transparent and rational one. Like Stahl (2012) noted, the discourse ethics — based on Habermasian rational discourse — is providing a mechanism to consider different moral views and intuitions. This kind of Habermasian (Habermas, 1996) rational discourse demands that subjects of legislation, have a possibility to take part in rational discourse whilst creating laws. This kind of legislative rational discourse is, of course, an ideal, but it seems trivial to note that there can be degrees of implementation of it. A government—and certainly no other actors—cannot wield arbitrary power over its citizens. Thus we see that we need this kind approach for eGovernment that drives commonly acceptable and ethical governance of eGovernment ecosystems instead focusing on mere efficiency and emphasising only views of some stakeholders.

6 Discussion and Conclusions

From the deontological perspective, eGovernment ecosystems cannot be straight evaluated as ethical or unethical because from this viewpoint there should be a free rational agent that can even make ethical decisions. An ecosystem (orchestrator) is not a rational agent in philosophical (ethical) sense but the decision-makers behind ecosystem and users of ecosystems are. Likewise the expressed intention — such gain efficiency — are in many cases just one side of the situation and other rationales are not visible for citizens. This kind of situation hardly can be seen as an ethical intention. This underlines the problem of the current power balance between the orchestrators (providers of the system and in the end, government) and users of systems — citizens.

Thus, form the consequentialist viewpoint the ecosystem can be ethical— if those hidden rationales have a good out- come for citizens and society. However, when we have those ecosystems we should ensure that also intention and virtue ethics are considered to ensure more broad ethical justification. For future research, there is a

need for an ethical framework for evaluating the ethicality of eGovernment ecosystems.

In this paper, we introduced an ethical approach based on three big ethical theories when evaluating the existing or building new ethically balanced eGovernment ecosystems by Discourse ethics. We find it justified to claim that the realisation of ethical ideals mainly set obligations towards the governments. However, it should not be assumed that positive ethical development will be ignited without external intervention. Furthermore, we claim that instead of relying on the support of organised parties such as legal authorities, the citizens and their demands hold a central role in steering the ethical development. This outlook is rooted in the fact that the primary function of regulative parties is to ensure that justified requirements of citizens —inside the limit of society's possibilities and resources — are fulfilled as citizens are the justified source of the power of the state.

Thus, the input and feedback from individuals have a crucial role in terms of setting ethical demands. However, it should not be assumed that the citizens take an active role, let alone responsibility, in building ethical eGovernment ecosystems. Thus, instead of setting concrete obligations towards the citizens, we propose that the governments develop their services based on their best understanding of the citizens' perspective and transparent public communication. To support this development, this paper aims to provide the governments with insights that help them to better understand the citizens' perspective and act accordingly to achieve truly functional eGovernment ecosystems.

Overall, the ethical considerations introduced in this paper likely manage to address only a fragment of all relevant ethical factors. Furthermore, we see that the high complexity of eGovernment ecosystems demands iterative approach to thoroughly identify the relevant aspects to be considered, and even then it is possible that all ethical factors involved in the ecosystems cannot realistically be addressed, let alone fulfilled in a way that results in truly balanced ethical foundations from citizens' standpoint. Regardless, the governments should give their best effort to honour good ethical principles when building and developing eGovernment ecosystems to ensure the safety of citizens and to maintain their dignity, which calls for further contribution from both governments and researchers aiming for creating ethically sustainable societies.

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IDENTIFYING THE OPPORTUNITIES FOR THE DESIGN OF DIGITAL PLATFORMS: A TOPIC MODELLING APPROACH

VEENA KANNAN[1], NORA FTEIMI[2], SAJI K MATHEW[1] & FRANZ LEHNER[2]

[1] Indian Institute of Technology Madras, Department of Management Studies, Chennai, India, e-mail: veenakannan1994@gmail.com, saji@iitm.ac.in
[2] University of Passau, School of Business, Economics and Information Systems, Passau, Germany, e-mail: nora.fteimi@uni-passau.de, franz.lehner@uni-passau.de

Abstract Aquaculture is one of the fast-growing food-producing agriculture subsectors. However, the digital infrastructures developed in aquaculture are self-organising platforms i.e. they do not rely on a centralized intermediary for monitoring, coordinating activities or for overseeing transactions. Hence, the main objective of this research paper is to identify the challenges farmers face in an entire supply chain for designing a digital platform for the aquaculture domain. The main problems faced by the farmers include water quality issues, disease outbreak, lack of proper information regarding suitable insurance policies etc. We have identified eight such issues that the farmers face in an entire harvest period and also prioritized them. The results from our study could be used for the further advancement of an integrative perspective in the design and implementation of the digital platform for aquaculture.

Keywords: digital platforms, aquaculture industry, topic modeling, challenges, water quality.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.15
ISBN 978-961-286-362-3

1 Introduction

Digital innovation includes carrying out new combinations of digital and physical components in order to produce new digital infrastructures (Yoo, Ola, & Lyytinen, 2010). Digital platforms are built and integrated on top of digital infrastructures. We define digital platforms as "*a set of digital resources— including services and content—that enable value-creating interactions between external producers and consumers*" (Parker, Van Alstyne, & Choudary, 2016). Digital platforms transform the transaction logic as they ease transactions between distinct supply chain stakeholders rather than handling the entire supply and logistics chain on their own (Hänninen, Smedlund, & Mitronen, 2018). For example, in the case of the automotive industry, subsystems (e.g., voice assistants or navigation systems) are becoming digitized independently but connected via vehicle-based software architectures. Hence, firms from other industries can also develop and integrate new products and services with the computing platform of the automotive industry (Henfridsson & Lindgren, 2010). However, in many industries, especially in agriculture (Bookie & Duncombe, 2019) and its allied subsectors like aquaculture (Mathisen, Haro, Hanssen, Bjork, & Walderhaug, 2016) there is a lack of centralized approach for distribution of content (e.g., tailored information regarding disease prediction, water quality parameters etc.). The digital infrastructures in the aquaculture domain are self-organizing platforms i.e. they do not rely on a centralized intermediary for monitoring, coordinating activities or for overseeing transactions between farmers and exporters (Forte, Larco, & Bruckman, 2009). Recent research shows that 80% of such platforms face challenges in ensuring content integrity which can undermine its survival (Tiwana & Bush, 2014). But, designing a digital platform upfront for a particular industry is challenging, as platforms change the power structure and relationship between different stakeholders (De Reuver, Sørensen, & Basole, 2018). Therefore, the main objective of this paper is to investigate how data-driven approaches can affect the design of collaborative digital platforms research from self-organizing platforms in the special case of aquaculture. In order to improve the design, we have to identify the problems faced by the stakeholders in each phase of the aquaculture supply chain (e.g. disease prediction, water quality monitoring etc.). Therefore, we would like to contribute to research by identifying and analyzing such occurring problems from prior literature.

According to the reports of Food and Agricultural Organization (FAO) in 2014, aquaculture will contribute majorly in the future to food security and adequate nutrition for the growing world population which is expected to reach 9.7 billion by the year 2050 (Subasinghe, Curry, Mcgladdery, & Bartley, 2003). Moreover, FAO also reports the challenges aquaculture is facing over the decades such as combating diseases, brood stock improvement and domestication, development of efficient feeding mechanisms, water-quality management etc. A decision support digital platform supporting the entire aquaculture supply chain has not received due attention in literature even though there is a considerable amount of literature for fisheries (Mathisen et al., 2016). Therefore, we integrate a list of identified factors from prior literature for designing a digital platform for the aquaculture industry.

This paper proceeds as follows: related work is outlined in section 2. Section 3 describes the research objective. In sections 4 and 5, we discuss the methodology and main results respectively and ends up in section 6 with a conclusion.

2 Related Work

A cursory examination of the literature on digital platforms reveals the diverse orientation of studies in this area. For instance, some studies were focusing on platform for healthcare, and some for platforms for energy informatics. In order to identify the key empirical studies related to the design of digital platforms, we conducted a systematic literature review (Webster & Watson, 2002) following a process of searching, filtering and classifying related papers. As the research on digital platforms started to appear in IS journals in the year 2002 (Asadullah, Faik, & Kankanhalli, 2018), we searched for articles between the period 2002 and 2019. We conducted a search in the databases of AISeL, IEEE, EBSCO and Google Scholar for accessing relevant journal publications and conference proceedings, using keywords "multisided platforms", "digital platforms", "two-sided markets" and their combinations and obtained 1000 hits. The papers were shortlisted first based on the title, after which we further shortlisted based on abstract relevance. Thereby, we included only papers dealing with the design factors of digital platforms in different industries and also research commentaries focusing on the design and governance of digital platforms (e.g. De Reuver et al., 2018). Research papers dealing with other topics like pricing, competition in digital platforms were excluded. Based on these criteria, a summary of 40 relevant articles resulted, which we used as base for our

analysis. The requirements of digital platforms along with the key stakeholders collaborating in the platform and some studies in the respective domains are mentioned in Table 1.

Table 1: Digital platform requirements in various domains

Digital platform domain	**Platform requirements**	**Stakeholders**	**References**
Agriculture	Reduction of information asymmetry, higher bargaining power and access to profitable markets.	Farmers, Buyers	Banker et al., (2011), Goyal, (2010), Jha, Pinsonneault, & Dubé, (2016)
Electricity	Competitive gaming platform have to enable dynamic electricity trading.	Electricity providers and subscribers.	Ketter, Peters, Collins, & Gupta, (2016)
Finance	Crowdfunding platform has to enable entrepreneurs to raise funds quickly	Entrepreneur, Funding agencies	Abhishek, Geng, Li, & Zhou, (2017), Hernando, (2007)
Healthcare	Patients data have to be managed in electronic health records, better healthcare assistance, higher productivity has to be ensured	Doctors, Nurses, Hospital administration and patients	Rodon, (2018), Agarwal et al., (2010), Jones, (2014)

3 Research Objective

The majority of studies performed in the Information Systems (IS) domain and its reference disciplines focuses on pricing (Rochet & Tirole, 2003) while neglecting technical, social and strategic aspects of the platforms (Pettigrew, Woodman, & Cameron, 2001). Moreover, the recent literature review by De Reuver et al. (2018) calls for more research on data-driven approaches to inform the design of digital platforms. Even though the decision support platform has been well studied in fisheries, there are lack of studies for the equivalent research in aquaculture (Mathisen et al., 2016). In order to fill these knowledge gaps, the main research objective of this study as follows:

How can data-driven approaches affect the design of collaborative digital platforms research from self-organizing platforms in the special case of the aquaculture domain?

4 Research Methodology

More than 80 percent of data today is stored in unstructured formats like audio, video, text etc. making it a difficult task to search, organize, synthesize and understand this huge corpus of information (Debortoli, Müller, & Junglas, 2016). To capture the problems faced by farmers in the aquaculture supply chain, we have analyzed the abstracts of leading aquaculture engineering journals and conference proceedings. There are supervised and unsupervised text mining approaches to classify textual data. Since the design choices of a digital platform are unclear, we rely on an unsupervised learning approach (e.g. Vidaurre, Kawanabe, Bünau, Blankertz, & Müller, (2011)) to allow the algorithm the autonomous identification of challenges faced by farmers in the text. The unsupervised approach allows us to discover the latent topics from the written abstracts. Latent Dirichlet Allocation (LDA), is one of the most widespread techniques used in the IS domain in order to identify common topics and their distributions (e.g. Rodriguez & Piccoli, 2018) from textual data (Eickhoff & Neuss, 2017). In the following, we provide more details on our dataset and the text mining approach used.

4.1 Data Sample

Research on digital infrastructures for aquaculture is relatively recent and therefore in an early progress stage. To get a broader picture of problems addressed by these infrastructures at different aquaculture supply chain phases, we collected articles from different databases such as EBSCO, Google Scholar and Scopus. We searched using the keywords "digital aquaculture", "machine learning and aquaculture", "artificial intelligence and aquaculture" and their combinations. To ensure quality, we focused on journals such as Sensors, Computers and Electronics in Agriculture, Aquaculture Engineering, Aquaculture, Reviews in Aquaculture and leading conference proceedings of IEEE, ACM. As a result, 50 documents over a period of 20 years were finally included consisting of 35 journal papers and 15 conference proceedings. After selecting the documents, we transformed the PDF files in image format to text format. This transformation was necessary for the subsequent text mining analysis. We focused the analysis on the abstracts and relevant parts of the introduction section, as inspecting the documents revealed that these parts already provided detailed information about the problems in the aquaculture supply chain and therefore fits well the purpose of this study.

4.2 Topic Modelling Approach for Data Analysis

Topic modelling algorithms are statistical methods for understanding latent topics inherent in text documents to help researchers summarize and interpret collected information along with topic labels (Blei, 2012). In our approach, feature extraction technique of Latent Dirichlet Allocation (LDA) and Rapid Automatic Keyword Extraction (RAKE) was applied using the statistical software programming software "R". LDA is one of the generative probabilistic algorithm commonly used in text mining and topic labelling (Blei, 2003). As an unsupervised learning algorithm, each document is treated as a bag of words to discover the latent topics from the distribution over words. During pre-processing, the data corpus was first tokenized by splitting sentences into words, removing punctuation, white space and numbers. After that, we removed stop words and performed stemming and lemmatization based on the WordNet database (Fellbaum, 1998). Subsequently, LDA was performed to determine the topics and their associated words. Prior to the analysis, we infer the optimal number of topics during an iterative procedure, which resulted in a number of eight topics that best represented the problems faced by farmers

during aquaculture cultivation. Topic labels can be compiled by grouping topic words to common-higher level themes. Human judgement can be used for performing topic labelling (Syed & Dhillon, 2015; Shi, Lee, & Whinston, 2016). Therefore, labelling of the problems faced by farmers and grouping into design features for platforms were performed by two independent researchers with extensive experience in digital platforms.

5 Results and Discussion

We computed the top words for each topic (figure 1 to figure 4) and also sorted topics according to their importance within the entire document collection (figure 5) using the gama function and theta function in R respectively. We also checked the document to topic probability to ensure the validity of the results.

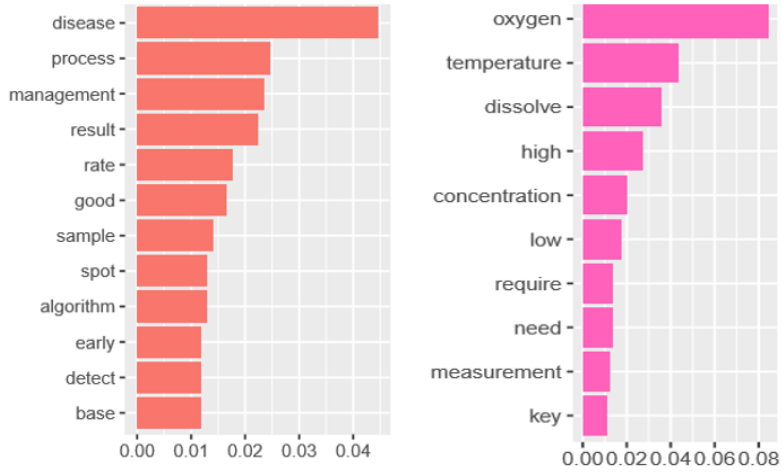

Figure 1: #T1: Disease prediction, #T2: Dissolved oxygen concentration prediction

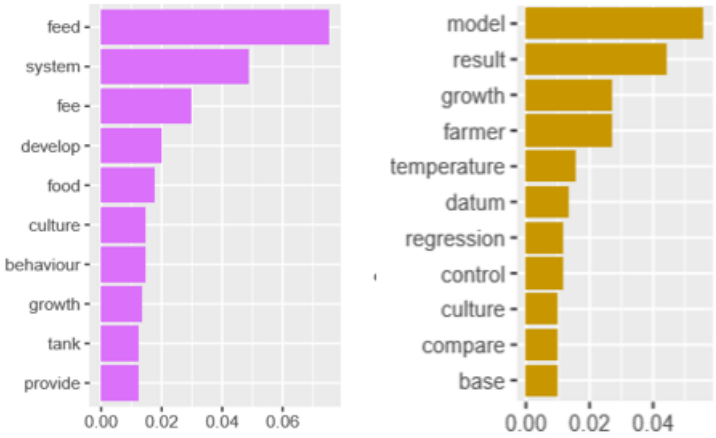

Figure 2: #T3: Feed parameters monitoring, #T4: Growth prediction

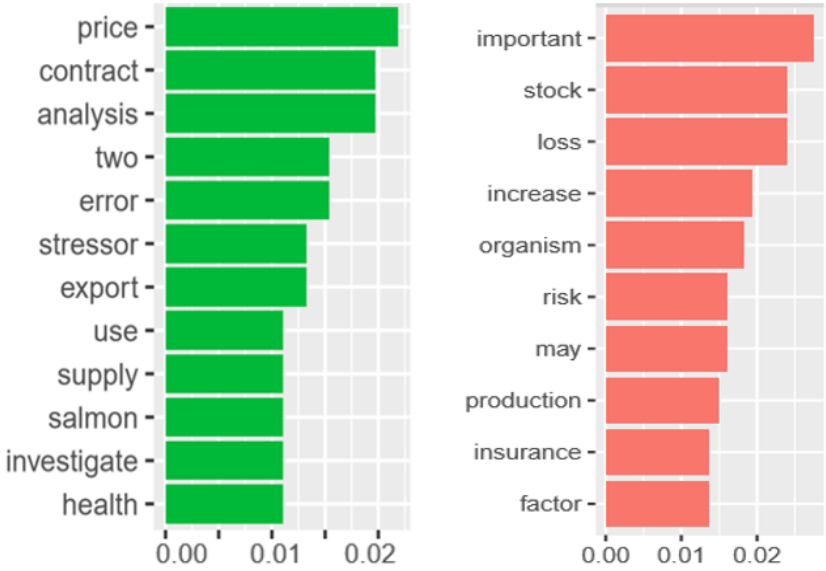

Figure 3: #T5: Market price prediction, #T6: Insurance policies available

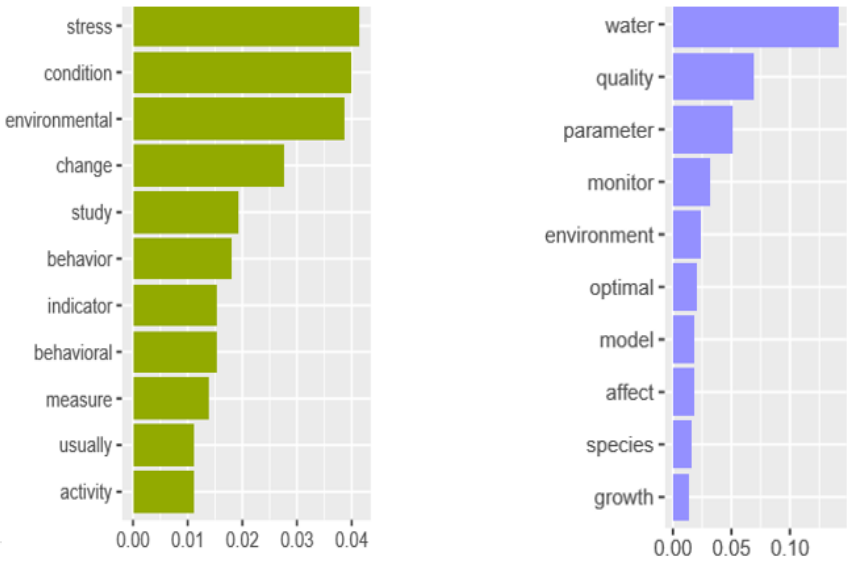

Figure 4: #T7: Behaviour monitoring & alerting, #T8: Water quality monitoring & alerting

As figure 5 shows one of the main problems faced by the farmers is the monitoring of water quality parameters (#T8). Water quality is an important aspect of aquaculture harvest and if any of the parameters are not at the optimum level may affect the animal health badly and can cause loss to the farmers (Piplani et al., 2015). In many of the aquaculture harvesting practiced in the developing countries, the farmers monitor these parameters manually and perform lab tests weekly. These traditional methods are amongst others time consuming, difficult for decision-making. Along with water quality monitoring and alerting the core of the platform can employ machine learning and artificial intelligence techniques for prediction of growth (#T4), disease (#T1), dissolved oxygen concentration (#T2) and monitoring of the behavior of the animal (#T7)(Yu, Leung, & Bienfang, 2006). The right amount of feed can also be automated, by the core of the platform as this accounts for major cost in the aquaculture supply chain (#T3). Along with the core, the main complements that need to support the digital platform from our analysis are insurance agents (#T6) and suitable exporters by predicting the market price (#T5). As aquaculture involves high risk as it requires estimating different parameters, the platform should be equipped to provide reliable farm level data to show proof for the insurance agencies in case of harvest loss (Secretan, 2008). Moreover, the farmers in traditional methods rely on intermediaries to find out suitable exporters. However,

with the digitalization of the aquaculture supply chain, the farmers could provide evidence for the quality of the product and bargain for higher value with a wide variety of exporters and choose the best price offered.

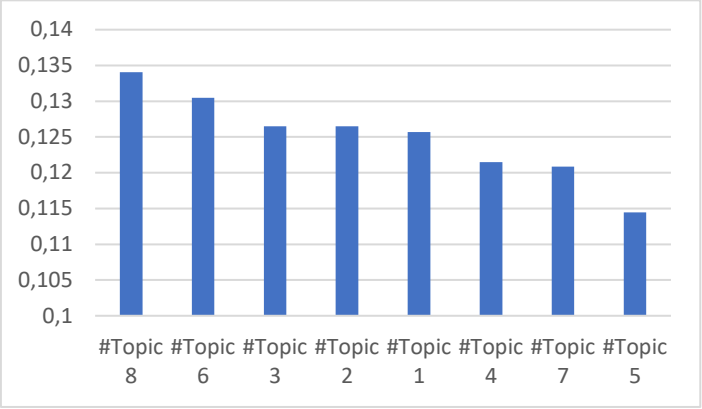

Figure 5: Topic Ranking

6 Conclusion and Limitation

In this study, we examined 50 digital aquaculture research works by applying machine learning approach of topic modelling. Our aim was to examine the factors that need to be considered while designing a collaborative digital platform from multiple self-organizing platforms in the case of the aquaculture supply chain. While there has been research on digital infrastructure in aquaculture in recent years, there is a paucity of studies that focus on the analysis, integration and temporal comparison of these infrastructures addressing problems faced by farmers in different phases of the aquaculture supply chain. The main stakeholders we identified from our data analysis for the digital platform are farmers, exporters and insurance agents.

The focus of our research was to understand the challenges the farmers face in an entire aquaculture supply chain. Our results bring out eight challenges in the aquaculture domain that have to be considered while designing a digital platform. Water quality monitoring, insurance policies available and feed parameters monitoring are some of the main problems that have to be addressed. Water quality parameters have to be controlled appropriately in the optimum range to increase the

fish growth rate and to reduce the outbreak of diseases (Stigebrandt, Aure, Ervik, & Hanson, 2004). After water quality, the second most important challenge identified in our research is suitable insurance policies. As the stock in aquaculture is grown in water, it is prone to unique risks and hazards unlike other industries (Secretan, 2008). Therefore, these are the two most important factors that have to be considered while designing a digital platform for aquaculture. Our results pinpointed that quantitative analytical methods such as LDA can be used for the analysis of qualitative data as that of research papers to get a bigger picture and insights for understanding the problems they address in general.

However, this study also has some limitations. The first limitation is the limited size of the dataset for topic modelling. However, as we included larger parts of the papers, our focus was not on quantity but on obtaining a detailed topic analysis of our specific text segments to identify concrete design factors for digital platforms. Future research can derive more insights into the problems faced by the farmers by including further textual data sources such as newspaper articles, data available on social media, blogs etc. Secondly, negation detection has not been considered in the algorithm. However, as we carefully inspected some text parts in advance during data preparation, we are confident that this limitation will not affect the final results substantially. Thirdly, with regard to methodology, topic modeling was the only method applied in this study. Future research can compare our results with the results from other methodologies like expert surveys for further verification. Moreover, future works could also focus on using design science principles to build a prototype version of the digital platform by considering the outputs from this research. Topics pertaining to the problems faced by the farmers in special contexts such as that of developing countries will be also interesting. The prototype can be verified to obtain validation of the literature results through direct interaction with farmers and expert opinion acquisition.

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A Tool to Model and Simulate Dynamic Business Models

Norman Schaffer[1,2], Martin Engert[1,2],
Girts Leontjevs[2] & Helmut Krcmar[2]

[1] fortiss GmbH, Guerickestraße 25, 80805 Munich, Germany, e-mail: norman.schaffer@tum.de, martin.engert@tum.de
[2] Technical University of Munich, Boltzmannstraße 3, 85748 Garching, Germany, e-mail: norman.schaffer@tum.de, martin.engert@tum.de, girts.leontjevs@tum.de, helmut.krcmar@tum.de

Abstract Software tools hold great promise to support the modeling, analyzing, and innovation of business models. Current tools only focus on the design of business models and do not incorporate the complexity of existing interdependencies between business model components. These tools merely allow simulating inherent dynamics within the models or different strategic decision scenarios. In this research, we use design science research to develop a prototype that is capable of modeling and simulating dynamic business models. We use system dynamics as a simulation approach and containers to allow deployment as web applications. This paper represents the first of three design cycles, realizing six out of 59 requirements that are collected from the literature on software tools for business models. We contribute toward the design of novel artifacts for business model innovation as well as their evaluation. Future research can use these results to build tools that consider and address the complexity of business models. Lastly, we present several options for extending the proposed tool in the future.

Keywords: dynamic business model, tool, simulation, design science, system dynamics.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.16
ISBN 978-961-286-362-3

1 Introduction

Companies need to develop innovative offerings to remain competitive (Amit and Zott, 2010). Business model innovation (BMI) has manifested itself as an important concept for theory and practice (Haaker et al., 2017; Marolt et al., 2018), and managers, in particular, should pay more attention to it (Pang et al., 2019). The impact of BMI has been regarded as superior to technological innovation (Chesbrough, 2007; Still et al., 2017; Teece, 2010). Thus, research on the methods and tools to implement BMI has become an important aspect in managing innovation (Amit and Zott, 2010; Becker et al., 2017; Schneider and Spieth, 2013; Teece, 2010).

With the abundance of data and computing power, software tools can perform the required modeling and analysis of business models (BMs) for innovation (Osterwalder and Pigneur, 2013; Szopinski et al., 2019). Numerous contributions have called for further advancement of the topic (Ebel et al., 2016; Szopinski et al., 2019; Veit et al., 2014) and even suggest to explore "…the application of computer-aided design tools to design tasks such as prototyping, simulating, iterating and versioning business models…" (Osterwalder and Pigneur, 2013). At the same time, the complexity to model and analyze BMs is rising. Particularly, the optimization of a BM for profit, growth, innovation, and robustness, while ensuring dynamic adaptation and strategic flexibility, are core use cases for managers (Cosenz and Noto, 2018).

However, most concepts, frameworks, and tools for BMs and BMI presented in the literature are inflexible and therefore limited in their use cases. For example, they allow for analyzing and representing the current state of a company's BM but fail to account for dynamic behavior or future states of a particular BM (Augenstein et al., 2018; Schaffer et al., 2019). Managers can be assisted in evaluating available alternatives of BMI and supported in ongoing decision making, through software-based artifacts, by performing simulations on a diverse set of strategic scenarios and BM configurations (Schaffer et al., 2019).

Therefore, the goal of this paper is to present a prototype of a tool that is capable of modeling and simulating inherent dynamics in BMs. With this study, we contribute to research on BM tooling and provide practitioners with a first version of an applicable artifact based on the completion of the first iteration within a design science research (DSR) cycle (Peffers et al., 2007).

2 Background and Related Work

2.1 Business Models and Dynamics

In prior research, numerous concepts and frameworks for developing and innovating BMs have been proposed (Arreola González et al., 2019; Marolt et al., 2016). According to Massa et al. (2017) BMs can be understood, among other interpretations, as formal conceptual representations of how an organization operates. As such, these concepts and frameworks describe the value creation, value delivery, and value capture logic of a venture (Teece, 2010). The Business Model Canvas, as a conceptual representation, has become the quasi-standard for representing BMs (Massa et al., 2017). Further, a variety of other frameworks are available. In our study, we utilize the business model component framework by Krumeich et al. (2012), which uses a component-based description similar to the Business Model Canvas, yet allowing to describe a BM in more detail, as it consists of 20 components.

With external upsets, rapid changes in legislation, and increasing competition, a BM and its underlying factors are subject to ongoing adaptation. This has led to the perspective of dynamic BMs, which can be defined as "…a complex system of interrelated sub-components of the value creation, delivery and capture mechanisms, which is interacting with heterogeneous internal and external influences leading to the evolution of its components and the system itself." (Schaffer et al., 2019). Compared to a static approach, a dynamic perspective recognizes BMs as correlated and complex systems of various elements. Furthermore, a BM is not only changed purposefully, but it is also exposed to inherent dynamics that occur unintentionally. The analysis of induced changes in a business model is crucial (Groesser and Jovy, 2016). In such complex systems, decision-makers require support to quickly take informed and effective decisions (Jere Jakulin et al., 2020).

One technique to model these dynamics is through simulation. By developing causal loop diagrams, the logical interdependencies in a complex and dynamic BM can be captured (Casadesus-Masanell and Ricart, 2010) and simulation models can be derived. A literature-based review of existing interdependencies between BM components can be found in Schaffer, Drieschner et al. (forthcoming). In the context of BMs, a suitable simulation approach is system dynamics (SD) (Cosenz and Noto, 2018). SD is a computer-aided approach to enhance analysis and decision making in complex systems (Moellers et al., 2019), and according to Täuscher and Chafac (2016) "SD focuses on identifying nonlinear causal relations in a system". As such, it accounts for nonlinearities, delayed cause-and-effect, and feedback relationships (Groesser and Jovy, 2016). However, building effective simulation models is a complex task and requires a deep understanding of simulation approaches. In practice, simulations can be used to evaluate different BM choices (scenarios) toward, for example, the adaptability, profitability, or robustness of a BM. However, to encourage practical implementation, the ease of use needs to be increased, since the typical consumer of the simulation outcomes is middle management, innovation managers, entrepreneurs, and potential investors. These consumers are typically only interested in the simulation results, and often hesitate to apply resources to model BMs required for simulation.

2.2 Extant Software-Based Tools for Business Models

To account for the complexity of BMs, managers use software-based tools to aid the process of modeling and innovating BMs. One well-known example is the e3-Value ontology (Akkermans and Gordijn, 2003). Other examples include Dellermann et al. (2019) who developed a decision support system for BM validation and Peinel et al. (2010) who described a modeling method to support the planning of BMs in the context of eGovernment work. Groesser and Jovy (2016) provide a quantitative approach for BM analysis, based on a SD-simulation, to address dynamic complexity in BMs and interactions of company initiatives, BMs, and their elements. Techniques have been proposed to identify the role of information technology (IT) in other areas, such as BM transformation, evaluation, and management (Augenstein, 2019; Rambow-Hoeschele et al., 2019; Terrenghi et al., 2017). In a series of papers, Athanasopoulo et al. provided a tool for BM development in the context of the Internet-of-Things, implementing prefilled BM templates and utilizing so-called solution-based patterns (Athanasopoulo, de Reuver, Haaker, 2018; Athanasopoulo,

de Reuver, Kosman et al., 2018; Athanasopoulou and de Reuver, 2018). However, the majority of the existing software-based tools are restricted to visualizing and designing a BM and do not offer simulation capabilities (Terrenghi et al., 2017). To our knowledge, no tools exist that offer the capability to simulate different BM design choices (i.e., scenarios), or that depict existing interdependencies between components to account for inherent dynamics.

3 Methodology

By definition, the result of applying DSR is "a purposeful IT artifact created to address an important organizational problem" (Hevner et al., 2004). An artifact may be a decision support system, a modeling tool, a governance strategy, an IS evaluation method, or an IS change intervention (Gregor and Hevner, 2013). Since the goal of this research is to create a tool that enables decision support, we adhere to the DSR guidelines for developing such an innovative artifact to an unsolved problem as proposed by Hevner et al. (2004) and Gregor and Hevner (2013). Table provides an overview of our DSR approach according to the process defined by Peffers et al. (2007). This approach entails creating an understanding of the context and the perceived problem, design a solution, interpret, and test the prototype with a real-world use case. Through this process we are aligning with prior DSR approaches on BM tooling, such as Athanasopoulo, Haaker et al. (2018).

Table1: DSR approach applied within this research, adapted from Peffers et al. (2007)

Step	Activities
(1) Identify Problem & Motivation	Identify the problem and highlight importance (Section 1 and 2)
(2) Define Solution Objectives	Select six requirements and derive concrete design principles (Section 4.1)
(3) Design & Develop	Implement the tool to develop and simulate dynamic BMs (Section 4.2)
(4) Demonstration	Apply the artifact to a case study (Section 5)
(5) Evaluation	Evaluate a problem-solution fit and determine requirements and improvements for the next design iteration (Section 6)
(6) Communication	Publish problem and proposed solution to receive feedback from academia

The first step of our DSR cycle is the problem identification and the motivation of the topic as in the first two sections of this paper. Second, we define the objectives and the requirements of our proposed software tool used for BM development and simulation. The third step, following the requirements and design principles, is to

design and implement the artifact for decision support. Finally, we demonstrate the artifact using a case study on a digital platform ecosystem for the German tourism industry. In our case, the platform owner uses the tool prototype to assess alternative options for the configuration of the value proposition in a first iteration. This iteration comprises the alpha and beta testing and an initial use case to show that the proposed tool can be used to solve practical problems (Hevner et al., 2004). We evaluate the artifact and derive conclusions regarding its functionality in the fifth step listed in Table 1 (Verschuren and Hartog, 2005). According to Prat et al. (2014), the instantiation and the demonstration of the use of an artifact is a valid evaluation. Particularly, we discuss preliminary results of the artifact and options for improvement in subsequent iterations. Finally, we conclude our first iteration by providing our insights to the community and by making the artifact available for further contributions from the scientific community (Hevner et al., 2004).

4 Artifact Description: Tool Prototype

In this DSR project, we focus on the design of a prototype that is functional for further evaluation, based on the requirements that we identified from the literature. In our first cycle, we created a working prototype of a software-based tool, which can model and simulate BMs and their components. In this section, we present the requirements and applied design principles, followed by the tool prototype.

4.1 Requirements and Design Principles

To define the objectives of the proposed solution, we obtained requirements and design principles for BM tooling based on existing literature (Peffers et al., 2007). We build on our prior work, during which we identified 59 requirements and subsequent design principles for BM tools based on a comprehensive literature review (Schaffer, Weking et al., forthcoming). These are 1) requirements regarding dynamic BMs and 2) general requirements toward BM tooling and decision support systems. Since this prototype represents the first design cycles of the overall research setting, we selected the most relevant requirements to create the first artifact, ensuring the relevance and practicality of the presented artifact. Within the first research cycle, we selected six out of 59 identified requirements (see Schaffer, Weking et al., forthcoming), which are listed in Table 2. Three researchers involved in designing the BM of the use case depicted in Section 5 were asked to prioritize

the requirements in a way that reflected their immediate needs. Based on this prioritization, we selected the requirements in Table 2, as they describe the core functionalities necessary for a running prototype and were prioritized by potential users.

Table 2: Requirements identified and selected for the tool prototype in the first iteration

Requirement 1: Build on existing BM representations and use a clear structure (Athanasopoulo, de Reuver, Kosman et al., 2018; Augenstein, 2019; Dellermann et al., 2019; Haaker et al., 2017; Schoormann et al., 2018)
Requirement 2: Users have to be able to customize the underlying BM to best fit a certain context (Giessmann et al., 2013; Szopinski et al., 2019)
Requirement 3: Provide features for specifying BM versions/variants to compare different solution options (Ebel et al., 2016; Schoormann et al., 2018; Voigt et al., 2013)
Requirement 4: Enable modeling of interdependencies between BM elements (Augenstein, 2019; Schaffer et al., 2019; Szopinski et al., 2019)
Requirement 5: Provide functions for simulating and financially evaluating a BM (Szopinski et al., 2019; Voigt et al., 2013)
Requirement 6: Facilitate collaboration across time, location, and organizational boundaries with the architecture of the tool (Dellermann et al., 2019; Ebel et al., 2016; Schoormann et al., 2018; Zec et al., 2014)

For the artifact specification, we selected subsequent design principles for the respective requirements. These also stem from prior work (Schaffer, Weking et al., forthcoming). Our goal was to specify a useable artifact, with design principles that can be easily comprehended and at the same time fulfill the requirements. The following design principles, as presented in Table 3, are used for implementation.

Table 3: Design principles employed to fulfill identified requirements for the tool prototype

Req.	Design principle	Description
R1	Use of existing framework by Krumeich et al. (2012)	Providing a clear structure by using an existing framework consisting of 20 components
R2	Individual creation, editing, and linking of components (Giessmann et al., 2013; Schoormann et al., 2018; Szopinski et al., 2019)	Allow customization by various editing and adjustment functionalities
R3	Creating different models and versions of them (Voigt et al., 2013)	Model management section to create and compare various models and versions of them
R4	Modeling of interdependencies between components and effects on existing interdependencies (Augenstein, 2019; Szopinski et al., 2019)	Function to create visual links as well as to create dependencies within the underlying functions used for simulation
R5	Definition of quantitative information within elements and interdependencies used for simulation (Szopinski et al., 2019; Voigt et al., 2013)	For each element, specific parameters, and mathematical functions can be defined and used by the simulation
R6	Containerized software as a web application (Zec et al., 2014)	The architecture as web application allows collaboration without regional or time boundaries

4.2 Tool prototype

The prototype of our tool is depicted in Figure. The bar on the left presents the hierarchical logic of our tool. After logging in, users can create a new project, for example, based on their use case, represented in the "projects" view. Within a project, a variety of BMs can be generated and simulated. The "models" section in the center of Figure is the modeling environment. This environment is based on SD (Forrester, 2009). To translate the concepts of SD into BMs, we used stocks from SD as BM components, while flows from SD were used to describe interrelations between the components. Stocks in SD describe entities that can accumulate or be depleted, such as resources. Flows are entities that lead to an increase or decrease in a stock, for example an adoption rate influencing the total number of customers. As such, one stock represents a maximum of one BM component; however, more than one stock can be used to model a component, e.g. different types of resources within the component resource model.

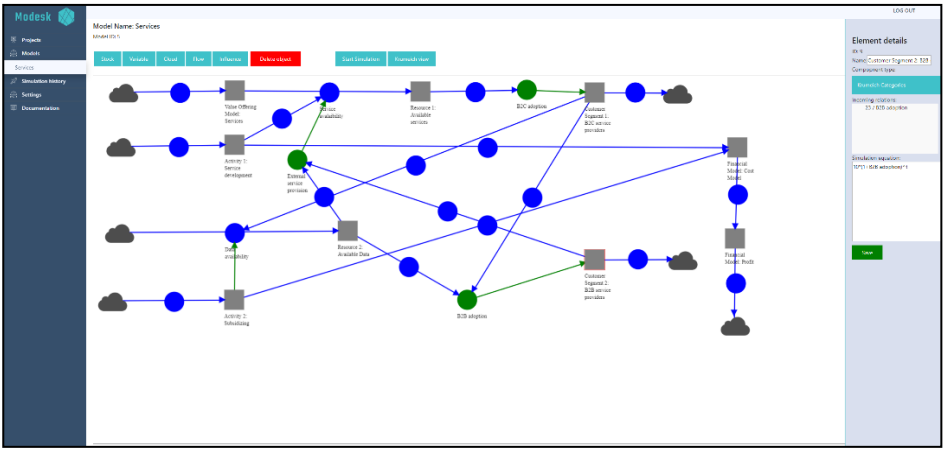

Figure 1: Tool prototype. Left: Navigation bar. Middle: Modeling environment depicting a case from a research project (see Section 5 of this research). Right: Editing section

Components can be grouped for better comprehension. We use the *Business Model Component Framework* of Krumeich et al. (2012) to describe each of the components, as it is a detailed framework consisting of 20 components, allowing us to capture the complexity of a BM and prepare it for simulation. In Figure 1, on the right, the editing section of an individual element is shown. Each element in the modeling environment can be described (element type, e.g., BM component; metrics, and equations for simulations) and edited individually. In the model depicted in Figure 1, the editing of the BM component Customer and Market Segment is shown. Users can choose the relevant BM component currently modeled from a dropdown list (turquoise button on the right), describe and edit the component, and define its metrics. The same is possible for additional variables and stimuli to create comprehensive models that are suitable for simulation. Once a model is created, users can run simulations directly in the modeling environment. If equations or metrics are missing, error warnings are shown for the respective components. Depending on the variables that have been defined, it is for example possible to simulate cash-flows for different scenarios. The simulations can be performed directly within the "models" section and be saved in the "simulation history" screen.

The prototype is designed as a containerized application, to allow easy deployment in different environments. To address the presented requirements and develop the prototype, we implemented the following technology stack:

- Docker for Containerization,
- Spring Boot, Angular, and Bootstrap for the application,
- MySQL for the database,
- Swagger for the API, and
- The simulation engine is self-developed and implemented in Java, following the rules of SD (Forrester, 2009).

5 Artifact Demonstration: Use Case of a Research Project Conceptualizing a Digital Platform Ecosystem

The use case to demonstrate our tool and its subsequent evaluation is a research project that aims to conceptualize a digital platform ecosystem for the German tourism industry. One relevant use case of the platform is connecting two customer segments: Business-to-business (B2B) service providers (component Customer Segment 2 in the modeling environment in Figure 1) and business-to-consumer (B2C) service providers (Customer Segment 1). Different key values are offered for both customer segments to get them on board (Engert et al., 2019). To provide value-added services, B2B service providers require a large amount of data to be exchanged through the platform. The B2C service providers are interested in the available services on the platform, which they can use and offer to their respective customers.

The success of this platform BM depends on the willingness of the B2C service providers to share their data within the ecosystem. If they provide sufficient data, B2B service providers are more eager to provide value-added services. The B2B service providers, on the other hand, are willing to create a service in exchange for data, as data monetization has become an important strategic option for many firms (Baecker et al., 2020). The platform BM has two options available:

- **Option 1:** Increase the BM component *Product and Service Offering* by increasing the number of available services (Resource 1) by, for example, creating services for the platform by the operator;
- **Option 2:** Increase the BM component *Resource Model* by increasing the amount of available data (Resource 2) on the platform by, for example, the operator paying B2C service providers to share their data.

Choosing either one of these options will have significant implications on the respective adoption rates, and thus on the growth of the platform and its BM. The complexity of the decision lies in the tradeoff between multiple future scenarios regarding the platform ecosystem. The proposed tool is capable of simulating this early stage, helping to evaluate the available options and resource investment decisions. In Option 1, creating own services, increasing the *Product and Service Offering* requires additional resources (Ressource 1), additional activities (Activity 1), and increased costs (Financial Model: Cost Model). Option 2, paying for the provision of data, requires additional activities (Activity 2), increased costs (Financial Model: Cost Model), and influences the customer relationship, the value proposition, and the profit (Financial Model: Profit). In Figure 1, only the relevant components of this setting are shown. Based on this model as depicted in Figure 1 and described above, both scenarios can be simulated.

The tool models these interdependencies and helps to understand occurring dynamics. Based on a set of assumptions and real-world data, it can be shown that Option 1, even though having higher initial cost (Financial Model: Cost Model), increases the overall adoption of the BM (the adoption rates of both customer segments increase stronger in this option than with Option 2) as well as the long-term profitability (Financial Model: Profit). Option 2 is more costly (Financial Model: Cost Model), and the costs increase even more with an increasing adoption rate by the B2C service providers (B2C adoption), while the adoption rate of B2B service providers is weaker.

6 Discussion and Conclusion

In this paper, we designed and evaluated a software tool to model BMs and their inherent dynamics. The proposed artifact is novel since existing tools hardly support the modeling of interdependencies between BM components and do not simulate dynamics or evaluate varied design choices.

Through our artifact, we contribute to research on BM tooling and dynamic BMs. For the two BM scenarios within the demonstrated use case, we successfully show the practical application of the tool and its' simulation functionality. We, therefore, contribute to the body of knowledge by showing that simulations and software tools, for complex BM decisions in practical settings, enhance decision support (Massa et al., 2017) in the context of BMI (Augenstein, 2019; Cosenz and Noto, 2018). Furthermore, we enhance literature on BM tooling by providing a tool allowing to evaluate different BM design choices and depicting interdependencies between components, thus accounting for dynamics (Osterwalder and Pigneur, 2013; Szopinski et al., 2019). At the same time, the tool is a step towards purposeful user-involvement in BM design and BMI.

This research is subject to certain limitations. Only a limited number of requirements have been realized, as we focused on the fundamental functionalities of our tool. The creation of simulation models is still complicated, not entirely accomplishing the goal of reducing the effort to conduct complex simulations. Furthermore, the evaluation of the tool prototype is demonstrated through the use of the artifact within a research project, with the BM being in a conceptual stage. Even though this is a valid evaluation method (Prat et al., 2014), additional iterations and more user feedback are required. For simulation, the tool uses SD-models, which are incomplete and can be extended and further validated (Täuscher & Chafac, 2016).

Based on this prototype and feedback received, we will expand the tool through case studies on the BMs of companies while continuing to evaluate the existing tool. The tool will be advanced by a new user interface and providing templates of generic patterns, building blocks, and where practical, entire models. More BM representations, such as the Business Model Canvas, will be implemented to allow selection of the desired framework by users. Further, we plan to implement a recommender system for modeling, which will reduce the complexity of modeling

and simulation. Automatic identification and notification of users of crucial dependencies between components is another option for advancing the proposed artifact. User involvement in BMI will be encouraged with a collaborative editor. In the tool's current form, for different scenarios, a model needs to be cloned and adjusted. However, for the updated design, we plan to implement the development and the evaluation of different scenarios within one model. Finally, a repository of models that have been developed with our tool could be provided anonymously and used as best practice guidelines for various practitioners.

Acknowledgements

This work was supported by the Bavarian Ministry of Economic Affairs, Regional Development and Energy under the BayernCloud project (grant. No. 20-13-3410-I.01A-2017).

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HEALTH 2050: BIOINFORMATICS FOR RAPID SELF-REPAIR; A DESIGN ANALYSIS FOR FUTURE QUANTIFIED SELF

LUUK PA SIMONS[1]

[1] Delft University of Technology, Faculty of Computer Science, Delft, Netherlands, e-mail: l.p.a.simons@tudelft.nl

Abstract About 75% of our healthcare costs go to four domains (cardio-, onco-, neuro- and metabolic) of diseases which are largely preventable or even reversible. Instead, they are 'managed' and made chronic, not cured. This is very costly and unsustainable for the future. Research is showing new opportunities for enhancing our body's self-repair in a matter of hours or days. We want to empower personal cure with rapid feedback for self-management. What could be an intervention- and bio-feedback portfolio to promote health self-repair within hours or days? Using a cross-case design analysis, we found large differences across the four health domains regarding: intervention aims, (self-)measurement options, focus on symptoms vs causes, plus degree of attention for health self-management. Given recent developments in rapid cure, we advise advanced daily bioinformatics feedback, instead of current quarterly cycles, to improve our self-repair effectiveness.

Keywords: health, self-management, quantified self, bioinformatics, service design, personal medicine.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.17
ISBN 978-961-286-362-3

1 Introduction

Many of the health beliefs circulating our society are outdated. Widely held views on aging, for example paraphrased as 'Many people assume that our manner of death is preprogrammed into our genes. High blood pressure by fifty-five, heart attacks at sixty, maybe cancer at seventy, and so on …' (Greger & Stone 2016, p. 5) have been refuted by a large body of recent health research (Lozano, 2012, Li, 2018, Willett, 2019). It turns out that key to our health is our self-repair: in virtually all our cells and tissues, damage is being repaired on a continuous basis (Li, 2019). This fact is largely unused by healthcare professionals, nor are we using how dynamically this can be improved (with biometric improvement feedback on an hourly or daily basis) by using healthy lifestyle choices on foods, exercise, sleep etc (Greger & Stone, 2016).

Unfortunately, health discoveries take decades to enter clinical practice (Balas & Boren, 2000) and old beliefs continue to pervade not just our society, but even our medical journals, especially regarding lifestyle and nutrition (Casazza, 2013). Analysis of the why, how and what of this problem, including the influence of fabricated pseudo-science by vested industries is a science in itself, see for example (Campbell & Campbell, 2016, Greger, 2019), and is outside the scope of this paper.

We must speed up adoption of health improvements which are based in solid science (Lozano, 2012, Li, 2018, Willett, 2019). We don't have the luxury to wait, since current healthcare practices are costly and unsustainable. Just as the Safeway CEO and the corporate Coalition to Advance Healthcare Reform have already calculated in 2009: with 74% of health costs arising from four conditions (cardiovascular disease, type 2 diabetes, obesity and cancer) which are largely preventable or reversible (Burd, 2009). Their disease processes take decades to progress and are sensitive to lifestyle (Ornish & Ornish, 2019). Thanks to recent insights, neurological (dementia) diseases can be tentatively added to this list: they are very costly as well, plus mostly preventable from cardiovascular and even Alzheimer's disease causes (Barnes & Yaffe, 2011, Barnard, 2014). And hopes are sparked by promising recent results in using broad spectrum health interventions to actually reverse brain damage and cognitive decline (Bredesen, 2018).

From a biological and health engineering perspective, some of the most promising recent health discoveries use our innate mechanisms for rapid bodily self-repair. In short, we want to help people experience and measure better health, possibly within a day, with rapid feedback of progress across a broad spectrum of health indicators.

We already knew the motto: 'Health happens between doctor visits.' Next, we would like to add: 'Health improvements can be shown overnight'. That is, if you use appropriate health interventions and feedback measurements. For design purposes, we take a '2050' view from the future, using 'optimism by method': on the one hand assuming maximum use of the dynamic nature of our biology for self-repair and on the other hand temporarily ignoring current healthcare barriers for adoption. Thus aiming for: what might be achievable in 'next level Quantified Self' for patient(citizen) empowerment and health improvement?

Our aim is to promote cure via rapid health self-repair feedback cycles. This needs an approach with personal iteration cycles, see Figure 1, using (Cross, 1994) goals analysis (problem space), intervention planning (solution space) and measurement portfolio (evaluation space).

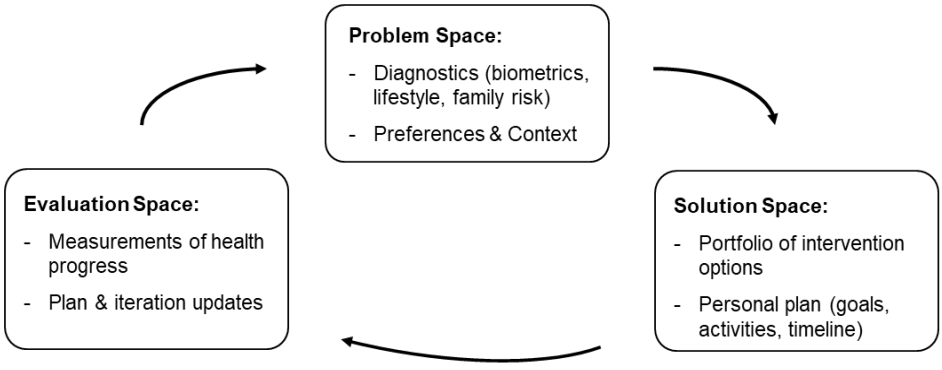

Figure 1: Personal iteration cycles for rapid health self-repair[1]

[1] This paper focuses mostly on the biology content and opportunities of self-repair. See Simons (2010, 2012 etc) for more details on the intervention processes and formats. Still, overall health iteration success depends on the full picture.

Thus, the main research question is: What could be an intervention- and bio-feedback portfolio to promote cure progression/health self-repair within days or weeks?

2 Method

Our research question is a design question. And the aim of this paper is to conduct a design analysis. The analysis is an example of design research rather than design science (Vaishnavi & Kuechler, 2004). Design science aims at generating knowledge on design, design research aims at generating (domain specific) knowledge for solving a given problem.
Our analysis will follow design cycle phases 1 and 2 of (Verschuren & Hartog, 2005): '1. first hunch' and '2. assumptions and requirements'. The design problem at hand aims to create personal support for people who want to make healthful lifestyle changes when faced with major life (-threatening) events like a heart attack or a chronic disease. Our 'first hunch' starting the design cycle is that personal health self-repair feedback on a (near-)daily basis may promote healthful behaviours and support health self-management choices.

To answer our main question it has to be broken down in sub-questions. Thus our main question regarding (near-)daily biofeedback for health self-repair will be covered via the design iteration sub-questions of problem-, solution- and evaluation space (Cross, 1994):

A) Which goals and ambition levels are feasible for health self-repair? (= Problem Space)
B) Which intervention and personal planning portfolio holds promise? (= Solution Space)
C) Which measurement and evaluation portfolio may aid progress? (= Evaluation Space)

Since our healthcare systems are hyperspecialized, it is no wonder that the four domains we focus on (cardio, onco, neuro and metabolic) vary widely in their current and emerging approaches on health, self-repair, patient empowerment, interventions or types of measurements. Given this diversity, we will conduct a cross-case analysis

across these four domains to find a first, exploratory set of answers to our research sub-questions. Our approach is similar to action research in the sense that we have a high level of 'access' to the current practices in these four domains[2] and at the same time we try to assess innovation options for health self-repair, given recent health discoveries as well as bioinformatics advancements.

3 Analysis

In sections 3.1 to 3.3 we answer the three research sub-questions. In each section we first discuss the differences and similarities across the cardio, onco, neuro and metabolic domains and then summarize the answers in a table. This cross-domain analysis provides the basis for the discussion and conclusion in section 4.

3.1 Which goals and ambition levels are feasible for health self-repair?

This section addresses feasibility of health self-repair. Given the space limitations here, we will refer to other sources for more extensive discussions of disease reversal options for each of the domains. For example, 'the book' on *cardiovascular disease* reversal was practically written by professor Ornish, not only with case-controlled proof of reversal early on (1990), but also with extensive follow up studies and publications (Ornish, 1998, Ornish & Ornish 2019). Still, this field is much broader (for an overview on this 'disease of affluence', see Greger & Stone 2016). And if we are looking for really fast health improvements, Jenkins et al (2003) have shown large LDL cholesterol reductions (-35%) within 14 days. More recently, the importance of vascular endothelial function has become clear for heart health. *Vascular function improves within hours of a healthy meal* (Murphy 2012, Lidder & Webb, 2013). As a motivating clip for young and old: the 'Game Changers' (2020) movie shows a humorous experiment halfway, where young athletes have over 300% percent improved erectile activity in the night directly after a healthy vegetable meal. Also for long term cardio benefits, lifestyle appears to trump medicine, as more extensively discussed elsewhere (Greger & Stone 2016). One example from that discussion. Statins are the most commercially successful drugs and most effective medication for cardiac disease. Still, a 100 people have to take the drugs (with all its side effects) for 6 years, in order to prevent a total of 3 heart attacks or deaths across

[2] By providing 6 months of lifestyle coaching (Simons, 2010, 2017) for literally thousands of patients and caregivers in all these domains, over the course of the past 10 years.

that group of 100 people. Lifestyle can do much better, with a 60% risk reduction of cardiac events in four years for 200 lifestyle participants of dr Esselstyn (2014), which is in line with the long term results of Ornish (1998). This again illustrates a further degree of disease reversal with lifestyle than with drugs. In conclusion, assuming people adopt the right health habits, the *cardio* domain holds much promise for adopting self-repair to enable faster, cheaper and better results.

For the *neuro(logy)* domain, a recent mantra has become: 'What aids heart health also aids brain health.' (Barnard 2014) We focus on dementia here, even though depression incidence shows remarkably similar lifestyle dependencies (McMartin 2013, Greger & Stone, 2016). The most common forms of dementia are cardiovascular dementia and Alzheimer's disease. Their worldwide incidence patterns show large variance similar to heart disease, depending on similar lifestyle patterns, which also help explain differences within Western populations (Barnes & Yaffe, 2011). Whereas prevention is quite feasible, treatment has proven itself difficult. No medication has been found that offers any form of cure, despite many multibillion dollar drug trials. According to dr Bredesen and others (Ornish & Ornish, 2019, Barnard, 2014) this is logical, since they were focusing on symptoms of brain defense (amyloid plaques), instead of addressing its multi-factor causes: usually inflammation, toxicity and the nutrient- and hormone-health of the blood supply (Bredesen, 2017, 2019). This asked for a multi-factor intervention program (across multiple health centers), which has shown large improvements for over 100 patients in for example memory, cognitive function and even hippocampus volume. Measurable improvements occur within weeks and in many individuals they last for years (Bredesen, 2017, 2019). In conclusion, and given the dire consequences of dementia in destroying your memory and personality, these are quite promising self-repair results indeed, driven by eating better and exercising better for example (Baker, 2010).

Regarding *metabolic* diseases, we focus on obesity and type 2 diabetes, since these are highly lifestyle dependent and they cause the majority of health and financial burdens of metabolic disease. Looking at the big picture: their worldwide incidence has very similar patterns to cardiovascular disease and dementia, with an important distinction that causation is more dependent on food patterns (overconsumption of high-energy-density junk- and animal foods and underconsumption of fibrous, whole plant foods) resulting in overweight, insulin resistance, glucose intolerance

and rapid aging at ever younger ages (Fuhrman & Sorensen, 2012). Fortunately, in terms of rapid repair, healthier eating and exercise can reduce medication needs within days and weeks, by improving insulin sensitivity, glucose tolerance and other health indicators (Simons 2016).

In terms of health self-repair, *oncology* is one of the toughest domains. On the one hand, we now know that the majority of cancer cases and deaths in the West are lifestyle dependent (lung, colorectal, prostate, breast cancer) with worldwide incidence patterns matching the previous diseases of affluence domains discussed. Several prevention strategies that work for the other domains, also help for cancer prevention (Campbell & Campbell, 2016). Unfortunately, 'Cancers are much easier prevented than cured. They are often diagnosed in their later stages, when they are harder to treat.' (Li, 2019) What does this mean for 'secondary' prevention, since most patients want to improve their health (risk) behaviors after the moment of diagnosis (Stull, 2007)? The good news is that we seem to be able to enhance our innate repair and defense mechanisms with healthy living. Not only in the initiation stage, but also in the growth and spread (metastasis) stages (Campbell 2017). And the less aggressive the cancer, the more healthy years this may buy us. For example, at three months as well as 5-year follow up, healthy lifestyle was successful for early prostate cancer (Ornish, 2005, 2013, Thomas, 2014). And for breast cancer, an average of five weeks between diagnosis and surgery was enough to significantly reduce tumor cell proliferation, enhance cell apoptosis and reduce metastasis risk in a randomized, placebo-controlled trial (Thompson, 2005). In summary: while healthy living prevention has most to offer for oncology, we are just beginning to scratch the surface of using our body's innate repair and defense mechanisms from the moment of diagnosis. And since tumors are more complex than atherosclerotic plaques for example, being able to try different lifestyle strategies and rapidly assess their impact (like we started doing for other cancer treatments) could be a very promising addition to personal treatment plans.

Table 1: Answers to: Which goals and ambition levels are feasible for health self-repair?

	Answer summary
Cardio & Metabolic	Promising health self-repair has been shown within days and weeks, with lifestyle repair trumping medicine.
Neuro & Onco	Neuro & Onco: both better preventable than curable. Neuro: first promising repair results with lifestyle. Hesitant progress in onco; some promising results.
Preferences & Context	Many patients make lifestyle changes around the moment of diagnosis. This is too often 'jumping to solutions' with insufficient considerations for evidence or quality of life preferences and context. Besides, public health prevention suffers from 'diluted' guidelines.

As stated in section 1, this paper focuses more on the biology- than on the process aspects of health self-repair planning, which have been discussed elsewhere (Simons, 2013, 2014, 2015, 2020). However, two process elements are important to highlight here. First, personal health choices are already highly prevalent around the moment of diagnosis, but often these are ill-informed choices. This is partly due to the fact that public health guidelines suffer from many forms of 'dilution', including (invalid) assumptions that people do not want to make big changes even if that would bring big gains. For a more extensive discussion see Greger & Stone (2016). Second, user preferences and (social-/family-) context matter a lot for the success of healthy living choices. But just like in other design settings, preferences can be highly dynamic, for example when health benefits are achieved. Thus they need to be part of explicit choices in the overall process.

3.2 Which intervention portfolio holds promise?

In terms of intervention options offered to patients, our first '2050' design goal is to achieve *significant measurable health improvements in the short term* (preferably hours, maybe days or weeks). Our second design aim is to make *optimal use of our body's innate repair and defense mechanisms*, given how precise and dynamic our body's own repairs generally are, if we don't actively distort them, see previous section (and for example Li 2019, Greger & Stone 2016). Third, we prefer interventions that also foster other long term health outcomes, thus creating *positive, instead of negative, side effects*. Our

fourth design goal may create trade off choices[3] with the previous goals: *attractiveness*, which includes broadness of choice and practical feasibility for the person/patient involved. This to increase healthy living motivation and long term sustainability.

So what do these four design goals mean for creating a suitable intervention portfolio (besides acknowledging that this portfolio must be sufficiently robust as well as flexible in the face of continuous evidence-based updates)? This is summarized in Table 2. An important question is how far we can come with 'relatively straightforward' generic health behaviors, or if we need very specific and personalized interventions? Fortunately, the research 'jury' has been out and is quite clear on this matter (Ornish & Ornish, 2019, Willett, 2019, Greger, 2019). For all our four health domains a few rules of thumb are valid. First, the health behaviors that best prevent a disease generally also best repair the damage. Second, we don't need separate 'health prescriptions' per domain: they are largely similar. The health benefits are to a very large extent (roughly 90%) achieved with the same core set of lifestyle behaviors regarding smoking, alcohol moderation, foods, physical activity, obesity, sleep and social support (Lozano, 2012, Ornish & Ornish, 2019), with genetics in these diseases counting for no more than 10%-20% at most (Willett, 2002). Some additional tweaks are sensible per conditions, see examples in footnote 3. Finally, as a third rule of thumb, the best lifestyle improvements are the ones that people actually continue doing, plus there is a dose-response: more behavior improvement means more health results. People best adopt plans and behaviors that they have chosen themselves (Gessnitzer & Kauffeld, 2015) and long term adherence is a combination of perceived behavior attractiveness, plus health benefits (Simons, 2020b). Thus, on a process level, personal goal setting and planning are important.

[3] For example, if people can create 80% of the expected results with only 2 lifestyle improvements, they will often prefer this to implementing 10 additional improvements for a next 10% gain.

Table 2: Answers to: Which intervention portfolio?

	Answer summary
Generic vs Personal Interventions?	From a biology perspective, generic health choices may provide a surprisingly large part (estim. 80%-90%) of expected results. Still, the *degree* of health improvement (which predicts results) largely depends on personal plans.
Cardio, Neuro & Metabolic	These three domains share similar mechanisms and lifestyle factors. With some detail adjustments for rapid repair boosting.[4]
Onco	Though repair mechanisms seem to benefit from healthy lifestyle, different cancers respond differently to lifestyle factors. Testing and adaptation needs to improve here.

One specific mention has to be made regarding the *oncology* domain and self-repair interventions. This field is still really in its infancy. Cancers do share many of the generic lifestyle factors with the other domains: smoking, alcohol moderation, foods, physical activity, obesity (Norat, 2010). But a large challenge is that different cancers appear sensitive to different lifestyle and dietary factors (see Gregor & Stone (2016) for an overview across many cancers), plus tumors are highly diverse. Even within the same person, colon cancer cells in one tumor may acquire more than 100 different DNA mutations over time, making tumor diverse in responding to changes in their environment (Langley & Fidler, 2007). At the same time, being able to test and assess rapid repair results from lifestyle interventions is important, in order to stop tumor progression early. This test cycle will depend on improved measurement and feedback, which is discussed in the next section.

3.3 Which measurement and evaluation portfolio may aid progress?

The area of health indicator measurements has enormously expanded over the past decades. And with the rise of *bioinformatics*, measuring genomics, proteomics, metabolomics etc, many new opportunities will emerge in the coming decades. Especially '*translational bioinformatics*,' bridging 'omics' and lifestyle diseases, including traditional public health biometrics (like oxidized LDL cholesterol, angiography for

[4] For example, salt reduction and endurance sports for endothelial function & blood pressure, low glycemic foods and resistance training for type 2 diabetes, and low-tox, high fiber foods for dementia.

plaques, or endothelial function via ultrasound or laser Doppler techniques for cardiovascular disease) is promising (Tenenbaum, 2016, Ravi, 2016). Still, the more options arise, the more important it becomes to be clear about measurement objectives and avoid 'jumping to solutions'.

If a measurement portfolio is to really empower individuals in their day-to-day health self-repair, this creates several design goals. We will start illustrating these design goals for the cardio domain, which has several lessons to offer, since it has the most extensive tradition of lifestyle self-management, measurement and feedback of the four domains. We discuss domain-specific issues in comparison to this *cardiovascular* reference.

A first goal is *reliability and validity* (including sensitivity and specificity): does it measure the relevant biological causal factors, and does it do so selectively enough? Second, the nice thing about the cardio domain is that we have learned to monitor behaviors (e.g. step counters), risk factors (e.g. blood pressure) and tissue health (endothelial function). In other words, our second goal is to measure a *broad array* of the most relevant inputs (like behaviors) and outputs (desired health results). A third goal is providing *rapid feedback*, since we are trying to capture hourly and daily improvements. Besides, our feedback aims also favor *Do-It-Yourself* (DIY) solutions, similar to current consumer blood pressure measurements, since regular home measurements provide a much more valid picture of the situation than a quarterly checkup at your doctor's. Fourth, given the aim for repeated DIY measurements, consumer market *cost/benefits* are important: they ideally are cheap, simple to deploy by an individual him-/herself and to interpret in terms of health behavior consequences. This latter step may often require some training by health professionals, like we do for LDL cholesterol or step counter readings.

If we compare the four domains we see large differences. The *metabolic* domain is close to the cardio domain in terms of DIY options with cheap, rapid blood sugar feedback for diabetics for example. (Although it's curious to see the focus on the symptom level readings of blood sugar or HbA1c, whereas insulin levels are much closer linked to biological disease causality. In terms of causal focus, the cardio domain is further ahead.) By contrast, the *neurology* and *oncology* domain have very few DIY measurement options, health feedback loops or even any health self-management support (apart from several cognition and memory tests that can be

done online). And a down-side in the neuro domain is a widely felt fatalism similar to 'we cannot help you anyway, so why bother with detailed diagnosis.' Bredesen complains that due to this fatalistic attitude even most neurologists omit many of the basic tests to confirm which type of Alzheimer's it is, and whether inflammation, malnutrition, toxicity or hormone imbalances are involved (Bredesen, 2019). Hopefully this will change in the future, since we now know these are modifiable health factors. Paradoxically, the onco domain is currently still the most dis-empowered in terms of health self-management (often treated by oncologists as being largely inconsequential compared to the tumor), however its emerging 'omics'/bioinformatics measurement portfolio may show us part of the route for the future, for two reasons. First, it stimulates development of 'omics' measurements, by for example routinely genotyping tumors and increasingly using biomarker assays for predicting recurrence or metastasis risk (Hatakeyama, 2017). Second, it has become increasingly normal to check within a few weeks whether a (chemo or immune) treatment is 'catching on.' This rapid feedback shows us the way for '2050' Quantified Self.

Table 3: Answers to: Which measurement and evaluation portfolio?

	Answer summary
Overall measurement goals	Reliability and validity, rapid feedback, broad (from behaviors to health results), Do-It-Yourself (DIY) options, consumer market cost/benefits (cheap, simple).
Cardio & Metabolic	Already some self-management measurement options available. Future consumer 'omics' can hopefully improve health feedback.
Neuro & Onco	Rapid growth of 'omics' feedback in the onco domain. This may soon aid better causal diagnosis in (multi-factor) neuro problems, next improve 'omics' health feedback for cardio and metabolism.

4 Discussion: Towards next level Quantified Self Bioinformatics

A previous '2050' vision for Quantified Self (QS) was crafted by Swan (2012). We would like to add 'next level' health ambitions to that vision. Quantified Self goals should mature further, beyond the focus (Swan, 2012) on data collection or research or prevention. The focus should be on cure and health. And the aim for QS bioinformatics to become a key contributor to health and cure results in 2050.

This aim is built on four premises. First, there is the rapidly growing array of options for rapid health repair feedback, see also section 3.3. Second, as discussed in section 3.2 and 3.3., health improvement and feedback options are generally welcomed by many patients around the moment of diagnosis. Third, research has increasingly shown that from a biology perspective, health self-repair is more effective than current 'best available' medical treatments (largely because self-repair is biologically more plausible and more advanced, thanks to millions of years of evolution) as discussed in section 3.1. Fourth, see also section 1, self-management for health repair is cheaper and supports a more sustainable healthcare system.

5 Conclusion

Health self-management has a lot to offer for a more sustainable and effective '2050' healthcare, if linked to bodily self-repair feedback cycles. This should be optimized for achieving and measuring health improvements in a matter of hours or days, based on insights from (near-real time and user friendly) bioinformatics. Especially when these data create a shared health progress view and dialogue with health professionals, this may promote truly collaborative health improvements in healthcare, with large and effective contributions from patients themselves.

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CONCEPTUALIZING THE AGILE WORK ORGANIZATION: A SYSTEMATIC LITERATURE REVIEW, FRAMEWORK AND RESEARCH AGENDA

MICHAEL GREINEDER[1], IVO BLOHM[1] & NIKLAS LEICHT[1]

[1] University of St. Gallen, Institute of Information Management, St. Gallen, Switzerland, e-mail: michael.greineder@unisg.ch., ivo.blohm@unisg.ch, niklas.leicht@unisg.ch

Abstract The ongoing discussion of the Agile Work Organization (AO) in research and practice permeates a multitude of research areas. However, no clear conceptualization of the AO has been provided. In this paper, we conduct a Systematic Literature Review to investigate what constitutes and defines the AO. The SLR reveals three dimensions in the research field of the AO: Strategic, Functional and Operative Agility. These dimensions define the AO through different unique capabilities by influencing and enhancing the overall goal of the AO in adaptation and flexibility. Building up on the insights from the review, we develop proposition which describe the interrelationship between the dimensions and towards the AO. Furthermore, implications for academia and practice as well as a research agenda are provided in order to trigger and guide further discussions and research surrounding the AO.

Keywords: agile, agile work organization, structured literature review, agility, framework.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.18
ISBN 978-961-286-362-3

1 Introduction

"Agility" and the "Agile Work Organization" are on everyone's lips right now. This applies to practice and research, which highlight the potential for innovation, sustainability and profitability. The concept of the Agile Work Organization (AO) with increased speed and flexibility is reflected in inconsistencies, overlapping and contradictory definitions, and different and heterogeneous mindsets. In IS-Literature agile information system development methods are discussed and based in dynamic work structures enabling organizations to deliver faster products for customers (Cao, Mohan, Ramesh, & Sarkar, 2013; Rigby, Sutherland, & Takeuchi, 2016)Recognizing these characteristics, IS scholars have analyzed the influence of these methods on firm's strategies, structures, and processes (Cao et al., 2013; Conboy, 2009; Tripp, Riemenschneider, & Thatcher, 2016). Management and organization science focus on the development of a new organizational logic to (re)organize resources and work arrangements in a digital world (Y. L. Doz & Kosonen, 2010). However, little attention has been paid to the question of the constitution of an AO and the relationship between the different research streams. The missing clarity about the exact nature of an AO makes it difficult to appropriately compare, analyze, and discuss the phenomenon. Consequently, we conduct a structured literature review (SLR), drawing on existing AO articles and prior AO studies, to present a framework of the AO, and furthermore provide an explanation, current state and connection between the different components by formulating propositions for the relationships between the different components of the identified AO dimensions.

This paper is organized as follows. First, the methodology is presented. Second, we present a definition and framework of the AO. Third we present the results of SLR, which consists of the identified three dimensions and six components and four propositions, which we identified from management, organization science, and IS literature. Finally, theoretical and practical implications, as well as limitations and prospective areas for future research of this paper are highlighted.

2 Methodology

Our research is a three step structured literature review according to Webster and Watson (2002) with the aim of better describing the area of agility in the organizational context and thus summarizing the relevant knowledge.

Step 1: Keyword-based search: We used a keyword-based peer-reviewed literature research. The first step led to the search terms "*agile*" OR "*agility*". We applied the search terms to the titles, abstracts and keywords of the publications. For the keyword search we used the academic databases EBSCO BusinessHost, Science Direct and Scopus. We performed the keyword search between March 2019 and May 2019. This step resulted in a total of 23,092 results. In order to reduce these articles to an analyzable number, and at the same time provide not only a comprehensive but also a specific set for our analysis, we focused only on peer-reviewed journals published in IS, management and organizational science outlets in leading A* journals or journals with an impact factor greater than 1.5. After applying this inclusion and exclusion criteria, 198 papers remained. Last, we excluded papers on other topics and papers that only marginally refer to agility by applying the definition provided by Sambamurthy, Bharadwaj, and Grover (2003) p. 245. Ultimately, 36 met all the inclusion criteria and provided us with a first set of papers to be included in the review.

Step 2: Concept-based (forward/backward) search: In addition to the keyword-based search, we conducted a concept-based search using reverse and forward search (Webster & Watson, 2002). For the backward search, we examined the 36 papers for citations from earlier sources and then obtained copies of cited sources that we considered potentially relevant. For the forward search, we looked for later sources that cited the 32 papers. In total, we reviewed 875 papers in this step (762 papers from the reverse search and 113 papers from the forward search). Thus, we identified another 16 relevant papers to be included in the review.

Step 3: Additional literature search: Finally, we have also searched for highly relevant papers, which were not part of the search results in the previous steps. This included collaborating with companies in research and practice, reading reviews and making recommendations from other channels. In total, we have identified another

six papers that were not already included in the two previous search forms. In total, our SLR identified 58 papers on agile or agility in the organizational context, including papers on agile or agility as part of a broader organizational use if they provide relevant insights.

The remainder of this paper contains an analysis and review of these 58 papers. Two experienced raters have independently reviewed the paper set using open coding for its content and paid particular attention to attributed characteristics, explicit and implicit definitions and key findings particularly relevant to AO. All authors confirmed the final coding of each article and discussed the coding differences until we reached a consensus; this helped to eliminate individual differences (Bullock & Tubbs, 1990).

3 Agile Organization definition and framework

As generally useful for an SLR, we use a clear definition of the phenomenon of the AO and a conceptual framework to structure the review. (Rowe, 2014; Vom Brocke et al., 2015). We compared the papers, supported by our own coding, to identify characteristics that can be consistently (across all papers) attributed to the AO. After reviewing the paper set, we were able to refine our definition of the AO to the following:

The agile organization increases its speed and flexibility (a) in fast changing environments (b) by a strategic orientation in sensing and responding, by (c) a functional alignment of knowledge and fluidity of resources (d) and by an operational team & working environment for optimal customer centric product delivery.

The definition of the AO has four components (a–d) according to the set of papers. *First*, the AO is in a turbulent environment of constant dynami c change. *Second*, agility, as in many business decisions, is a strategic orientation of the organization. In our review, we found that sensing and responding are key points for the strategic orientation of an AO. *Third*, the AO must be able to bridge the gap between organizational strategic sensing and operational product delivery. The alignment and the fluidity of resources should be flexible with both dimensions. *Fourth*, agility is on an operational level based on agile methods for the rapid development and

implementation of customer-centric products. Figure 1 shows the synthesis of the literature into a framework that allows us to structure the review in a concept-oriented way using important components of the AO phenomenon (Rowe, 2014; Vom Brocke et al., 2009; Vom Brocke et al., 2015; Webster & Watson, 2002). Accordingly, the purpose of the framework below is to support a better conceptual understanding of the AO and to provide a structure for our analysis of the identified papers.

The AO framework has three main components. The "Strategic Agility" component covers critical capabilities of organizations to identify or sense and respond to relevant changes for sustainable business strategies. The "Functional Agility" moderate and align strategic agility with the operational circumstances. Finally, "Operational Agility" component encompasses insights regarding the optimal use of different working systems and product delivery in the right environmental setting. The horizontal arrows indicate the direct and indirect effect of the dimensions on the overall goal of AO. The vertical arrow indicates the environmental forces on the respective dimensions.

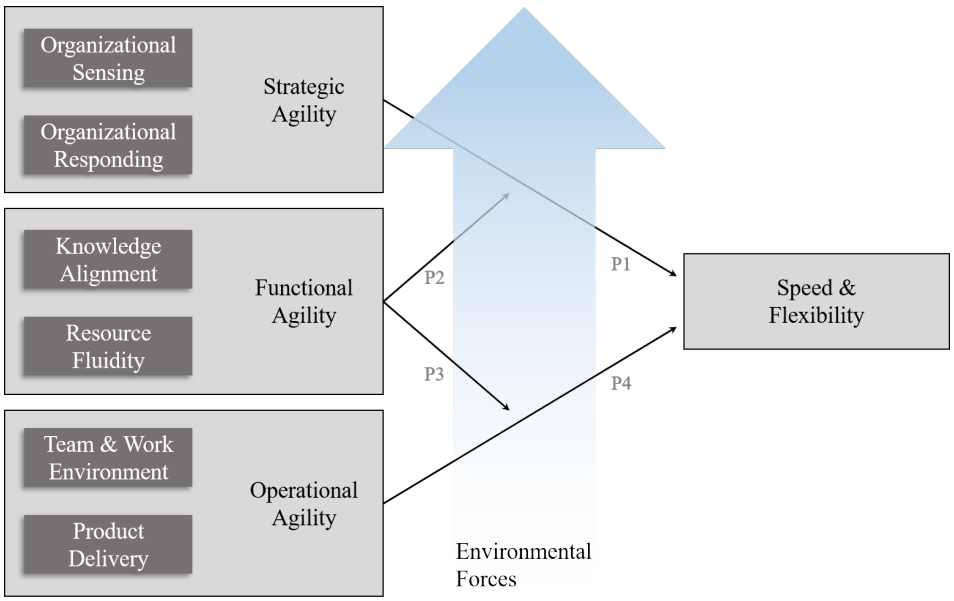

Figure 1: Agile Work Organization Framework

4 Analysis

In this section we discuss the state of knowledge about the AO, which is structured according the conceptual framework depicted in Figure 1. For each component of the framework we first give a definition and then go into detail on individual research directions. Finally, we formulate propositions denoting the effect in each of the dimension and for further research.

4.1 Strategic Agility

We refer to *Strategic Agility* as the ability of organizations to use business processes to achieve *speed, accuracy* and *cost savings* in the exploration and exploitation of innovation and competitive opportunities. (Y. Doz & Kosonen, 2008; Overby, Bharadwaj, & Sambamurthy, 2006; Park, El Sawy, & Fiss, 2017; Sambamurthy et al., 2003). The concept presented by Sambamurthy et al. (2003), which was further elaborated and refined (i.e. (Overby et al., 2006; Park et al., 2017)), identified the ability to (1) *identify* or *sense* and (2) *respond* to relevant changes as critical capabilities of organizations for shaping sustainable business strategies (Battleson, West, Kim, Ramesh, & Robinson, 2016; Overby et al., 2006; Park et al., 2017; Sambamurthy et al., 2003; D. Teece, Peteraf, & Leih, 2016).

Organizational sensing, which itself is defined as the systematic monitoring of environmental change in different areas within and outside of the normal business context (Overby et al., 2006; Park et al., 2017). Sensing requires to simplify information and to properly take action (Weick, Sutcliffe, & Obstfeld, 2005), by labeling and interpreting the relevant information (El Sawy, 1985). However, capturing the dynamics and context of environmental change involves a social systematic (Weick et al., 2005), where a dedicated knowledge acquisition process of an organization is supported by a strong network of knowledge (e.g. interacting with customers and suppliers). Thus, knowledge conversion into new explicit knowledge opens up pathways for knowledge exchange and promotes knowledge exploitation across different entities, which is important to highlight organizational strengths and weaknesses in light of external environmental changes (Mavengere, 2013). *Organizational Responding* is the decision making process within the organization of consolidating, classifying, and assessing the information collected from various internal and external sources with the goal of understanding the impact of

opportunities and threats in order to define an action plan as response to maximize opportunities and minimize threats (Houghton, El Sawy, Gray, Donegan, & Joshi, 2008; Kester, Griffin, Hultink, & Lauche, 2011; Park et al., 2017). The link between organizational sensing and taking action in organizational responding is given by workforce agility and enabled by empowered autonomous teams (Goldman & Nagel, 1993; Van Oyen, Gel, & Hopp, 2001). Building relationship over platforms that increase entrepreneurial alertness within the organization is supportive, as employees are more willing to share their ideas and build on each other's comments and actions (Matook & Maruping, 2014).

In the following, we can summarize the previous explanations on the proposition P1: Strategic Agility positively influences the speed and flexibility of organizations through organizational sensing and responding.

4.2 Functional Agility

The functional agility underlies two abilities (1) the alignment of knowledge and (2) the fluidity of resources to enable the strategic and operational side of an organization to co-evolve through joint optimization and adaptation (Vessey & Ward, 2013; Vidgen & Xiaofeng, 2009).

Knowledge Alignment is a product of shared knowledge and understanding between individual business units (Kearns & Lederer, 2003; Preston & Karahanna, 2009; Reich & Benbasat, 1996; Roberts & Grover, 2012). A proactive and dynamic view of corporate direction ensures continuous learning and renewal to avoid competence traps and enable co-evolution between business units (Vidgen & Xiaofeng, 2009). Organizations with a progressively adaptable knowledge alignment enable business units to benefit from both tacit employee knowledge and explicit organizational knowledge. Thus, it enables organizations to create new promising business opportunities and increase business value in the face of environmental change (Anand, Coltman, & Sharma, 2016).

Resource fluidity denotes an organizational internal ability and integral component to redeploy resources timely in response to change (Y. L. Doz & Kosonen, 2010; Paul P. Tallon & Pinsonneault, 2011). Resource fluidity is needed by all stakeholders to develop an informed and coherent transformation strategy, which has the capacity to respond to required product and business model adjustments (Mavengere, 2013). However, aligning strategic and operational agility requires embedding IT in critical business processes to enable rapid response to process changes (Paul P Tallon, 2007). The basic consideration is to align or expand the existing resources as efficiently as possible (Oh & Pinsonneault, 2007) by trying to mitigate the general tension between long-term commitment of resources with the current strategic orientation of agility (Kelly & Amburgey, 1991). Resource fluidity-induced exploitation and exploration of important organizational resources stimulates innovation and adaptation between strategic and operational alignment of business processes (Gupta, Smith, & Shalley, 2006; He & Wong, 2004; Kraatz & Zajac, 2001). As outlined Functional Agility moderates the effect of the Strategic- and Operational Agility on Speed and Flexibility and enables us to formulate the following two propositions:

A higher degree of knowledge alignment positively impact Sensing and Responding (P2). The higher the degree of resource fluidity, the greater the impact on faster customer-oriented product delivery (P3).

4.3 Operational Agility

Acting on environmental change is the reconfiguration of resources to adapt business processes or to redesign the organizational structure in such a way that the customer quickly receives added value (Augustine, Payne, Sencindiver, & Woodcock, 2005; Daft & Weick, 1984; D. J. Teece, Pisano, & Shuen, 1997).

The *Team & Environmental* ability denotes the optimal and effective use of applied work techniques, which influences various factors such as structural characteristics, IT, mindset, work characteristics, organizational context and interaction style, employee empowerment, knowledge and experience (Augustine et al., 2005; Cao et al., 2013; Mangalaraj, Mahapatra, & Nerur, 2009). Highsmith (2009) therefore argues that decentralized decision-making in an autonomous team is a core element of agile work (Augustine et al., 2005; Boehm & Turner, 2003). And, in which team members

are able to make decisions on the best information available (McAvoy & Butler, 2009; Tata & Prasad, 2004; Vidgen & Xiaofeng, 2009). Literature suggests that the internal diversity of a team (e.g. age, gender, education, etc.) should match the diversity and complexity of its environment (Goh, Gao, & Agarwal, 2011). Sharp and Robinson (2004) discovered that high performance teams work effectively in a tight, informal environment. *Product Delivery* as another ability, focus on "customer agility" on the product development level. Customer agility places particular emphasis on agile development methods, which in turn strengthens the agility of the product delivery (Maruping, Venkatesh, & Agarwal, 2009). Agile methods require a product environment in which developers can dispense plan-driven development processes and quickly integrate product components desired by customers (Harris, Collins, & Hevner, 2009; Maruping et al., 2009; Shihao et al., 2018), but also allow organizations to monitor, change and improve production processes in real time (Harris et al., 2009). The results indicate that the dynamic performance of an organization has a significant positive impact on the operational processes of the work units that design, manage and implement new products. And, agile workflows allow organizations to monitor, change and improve production processes in real time (Harris et al., 2009).

Hence, operational agility positively influences speed and flexibility through optimal customer-centric product delivery (P4).

5 Conclusion and Implications

In this paper, we conducted a literature search to investigate and identify important dimensions and components of the AO. In total, the SLR showed three research dimensions: Strategic Agility, Functional Agility and Operational Agility and four proposition within our presented framework.

Within our presented framework we present the different components within each dimension, and additionally the relationship and dependencies of each dimension to the overall goal of Speed & Flexibility within the AO. The outlined four propositions (P1-P4), which denote the currently missing links between the identified research dimensions allow scholars to identify within the different dimensional level the impact on Speed & Flexibility on AO.

The **theoretical implication** of this paper is the clear definition and conceptualization of the novel phenomenon of AO and a comprehensive overview of research results and findings relevant to the AO. The review enables a clear conceptualization of the AO in (1) Strategic Agility, as the company's ability to capture environmental impacts and develop a concrete, overarching organizational response strategy, (2) Functional Agility, as the ability to mediate between strategic and operational agility with the alignment of knowledge and the fluidity of resources to enable rapid action with the necessary resources, and (3) Operational Agility, the ability to make optimal use of working methods and environment to deliver fast customer-focused products. In our developed framework, we present the different components within each dimension, as well as the relationship and dependencies of each dimension to the overall goal of Speed and flexibility within the AO. The four developed propositions (P1-P4) describe the direct influence between the dimensions and on the AO as a whole. This allows scientists to identify and describe the effects on speed and flexibility on AO within the different dimensions.

The **practical implications** of our work results are of high relevance for a successful transformation towards AO. However, the transformation process is limited if organizations do not take a balanced approach within the agility dimensions. Our presented framework can help practitioners to plan and classify their transformation intentions and to evaluate the impact of the implemented objectives. In addition, it allows to identify areas where improvements can be made to support the overall agility initiative. In particular, the identification in the interaction of the individual dimensions through the presented propositions can help practitioners to identify problem areas and blind spots.

6 Limitations and Research Agenda

Despite our attempt to rigorously analyze the identified literature on AO, this SLR has several limitations. First, the scope of the SLR is not completely exhaustive in all areas of AO. In addition, the selection of relevant papers is a process that involves subjective judgement. Finally, we limited the initial keyword search to titles, abstracts and keywords to ensure that the keywords appear close together in the text, as we were interested in the interaction of different components in the AO.

A prospective area for further research may aim to analyze the relationship, relative importance, interactions and appropriateness in different contexts between the different strategic agility characteristics of the AO. This means which way and configuration of strategic agility and which parameters are best suited for certain circumstances and how can these be achieved and measured? Functional agility was a particular focus of research (Kwon, Ryu, & Park, 2018; Mavengere, 2013; Vessey & Ward, 2013). Despite extensive research, no general model was identified that would motivate to close the gap between strategic and operational agility. Particular aspects in the area of resource redistribution and knowledge management were addressed (Kearns & Lederer, 2003; Preston & Karahanna, 2009; Reich & Benbasat, 1996; Roberts & Grover, 2012). However, there is no clear overall link to the individual components to the other dimensions of the AO. Particularly in the area of strategic agility, the connection between essential resources and the resulting advances in knowledge in sensing needs is missing. In addition, some of the mechanisms mentioned above are not sufficiently understood in operational agility. We do not know much about the process of transforming companies into agile practices and how it can be mastered. Future research must examine how companies proceed or could proceed to define the conditions in which agile practices can be successfully implemented. A better understanding of this process will also help us to understand what kind of work in its nature can be optimally replaced by agile forms of work and can contribute positively to business success. Another relevant question that has not yet been researched is the measurement of the AO's objectives and their short, medium and long-term effects. Concepts for measuring and benchmarking organizations and in-depth longitudinal studies could shed light on the effects of the AO, including its less obvious and long-term effects on topics such as corporate climate and culture, innovative strength, business value, and profitability.

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AGILE LEADERSHIP - A COMPARISON OF AGILE LEADERSHIP STYLES

MICHAEL GREINEDER[1] & NIKLAS LEICHT[1]

[1] University of St. Gallen (HSG), Institute of Information Management, St. Gallen, Switzerland, e-mail: michael.greineder@unisg.ch, niklas.leicht@unisg.ch

Abstract Leadership has been the focus of research in the social sciences since the early 1930s. However, no generally valid theory exists to date. In recent years, theories relating to agile leadership have also increasingly emerged. The aim of this paper is to give an overview of the current state of research on agile leadership. For this purpose, a systematic literature analysis is conducted. The different terms used in the context of agile leadership are restricted by means of selection criteria. Furthermore, characteristics of agile leadership will be analyzed and consolidated. This results in a catalogue of criteria with which the selected leadership styles. The evaluation shows that there are overlaps in the styles, which also can be identified in the research.

Keywords: agile, leadership, literature review, comparison, research paper.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.19
ISBN 978-961-286-362-3

1 Introduction

"Agility" has increasingly become a trend word in recent years. More and more organizations are trying to become "agile" and implement agile corporate structures. This refers not only to the processes and structures they adopt, but also to the way leadership is designed (Joiner & Josephs, 2007, p. 35). Leadership is a concept that is constantly evolving as a result of social changes and their impact on the world of work and expectations of the role of a leader (West, 2004, p. 28). There is no generally valid theory of leadership (Bolden, 2004, p. 3). Rather, researchers, academics, and consultants have introduced a wide variety of definitions and concepts of leadership over the years, some of which differ only slightly from one another. In recent years, a variety of theories on agile leadership have appeared in academia and in practice. The unmanageable amount of theories and terms concerning (agile) leadership makes a uniform understanding of the concept difficult.

In this context, this paper gives an overview of the current state of research on agile leadership. The relevant leadership concepts are identified, presented, compared and similarities and differences are highlighted.

For the development of an overview of the current state of research, a five-step systematic literature analysis according to vom Brocke et al (2009) was chosen. First the scope of the literature search according to Cooper (1988, p. 109) is defined.
The second chapter thus provides a theoretical basis as well as an overview of the terms. The third chapter, is the literature analysis and synthesis, and forms the core of the present work. For this purpose, the literature on the different agile leadership styles and concepts is systematically compiled and analyzed. The work is rounded off by the creation of a research agenda based on the results of the previous steps. The aim is to identify research gaps in the existing literature on agile leadership and possible questions for future research.

2 Conceptual Background – Leadership

In the literature there are many attempts by scientists to define the term leadership. According to Bass (2008), the search for a single definition of leadership is futile, as the definition depends on the researcher's interest and the nature of the problem or situation. In an integrative approach, Winston and Patterson (2006) examined 160 articles in a meta-study, whereupon the authors identified 91 dimensions of leadership. The high number of dimensions shows the complexity of the concept and that a large number of aspects must be taken into account when defining leadership. The view that leadership requires the consideration of different perspectives is supported by other researchers. For example, the authors of the book "What is Leadership?" propose to consider leadership on five levels (Grint, Jones, Holt, & Storey, 2016, p. 4). Leadership can thus be considered in terms of the person (you are a leader if you have followers), the outcome, the process, the purpose, or the position. The authors conclude that leadership contains all five levels and at the same time none of them (Grint et al., 2016, p. 16). Thus, it is assumed that leadership is a complex construct that allows much freedom for subjective interpretations.

Definition of Leadership: First traditional approaches to leadership are based on the characteristics of a leader (Robbins & Judge, 2010, p. 369). Thus, the innate personality was originally seen as the crucial difference between a leader and a non-leader. Stogdill (1950, p. 11) described the purpose of the leadership process in terms of achieving common goals. Kotter (1988) also regarded leadership as a process, but in his definition took into account the use of non-coercive means. He defined leadership as "a process of moving a group (or groups) in a certain direction with mostly non-coercive means". For this purpose, he said, a leader was required to design and share a vision (Handy, 1992). After research had considered leadership as a set of characteristics, processes, or specific behaviors, the understanding was expanded to include another aspect, that of contingency theory (Robbins & Judge, 2010, p. 373). Based on the results of the literature review, the working definition of leadership in this paper is as follows: Leadership refers to all aspects (goal, role, position, process) of influencing a group in a particular context to achieve a vision or set of goals.

Working definition of Agile Leadership: Since literature provides no uniform understanding of agile leadership and its embodied different aspects: We view agile

leadership as a way of thinking and attitude, as role and characteristics of the (agile) leader, as leadership of agile teams, or as leadership practices and processes. The working definition of agile leadership, which is derived from the definitions of terms and literature analysis, is defined as follows Agile Leadership encompasses those mindsets, leadership styles and practices, as well as the characteristics and competencies of leaders, which are designed to support a rapid response of an organization to changing environmental conditions and are therefore particularly suitable for the leadership of organizations with flat hierarchies. The literature analysis shows that the number of leadership styles associated with agile leadership is large. However, it shows that many terms are not established concepts. In contrast to leadership in traditional companies, the perspective moves away from the process view towards people and their characteristics (Table 1).

Table 1: Leadership in hierachical vs. agile Oraganizations

Levels	**Leadership in hierarchical organizations**	**Leadership in agile organizations**
Mindset/ Attitude	Increased efficiency and clear division of tasks for maximum output	Understanding environmental change as a permanent state
Leadership role	Decision maker, sole responsibility of the leader	Empowering the team, creating appropriate conditions, shared responsibility
Team organization	Clear hierarchical positions and distribution of roles between leader and follower, responsibility at Leader	Self-organized teams, flat hierarchies, independent working methods, focus on collaboration, shared responsibility
Management practice	Process view, sequence of different activities	Common vision, teamwork, collaboration, simple rules, open flow of information (e.g. through Scrum, Kanban or Lean Management)

3 Methodology

In this chapter, agile leadership styles are identified and compared using a structured catalogue of criteria. The goal is to show similarities and differences between different agile leadership styles and to critically question them.

3.1 Selection of Agile Leadership Styles

The extensive literature research provides numerous leadership styles that are relevant in the context of agility.

Table 2: Different Leadership Styles

The new deal at the top (NDT)	Visionary Leadership (VIL)
Servant Leadership (SEL)	Situational Leadership (SIL)
Transformational Leadership (TFL)	Transactional Leadership (TRL)
Promise-based Leadership (PBL)	The connected Leader (TCL)
Shared Leadership (SHL)	E-Leadership (ELE)
Agility and absorption (AAA)	Complexity Leadership (COL)
Executive as a coach (EXC)	Distributed Leadership (DIL)
Emergent Leadership (EML)	Digital Leadership (DGL)

In a next step, the knowledge gained is narrowed down using selection criteria. The aim is to analyse only those leadership styles that meet certain formal and content-related requirements. Specifically, it is examined whether the search results of the listed leadership styles meet the following criteria (see Table 3):

Table 3: Selection Criteria Leadership Styles

1	Scientific style of the published work (WS)
2	Reference to the definition of agile leadership (FC)
3	Mentioned in mind. four peer-reviewed scientific paper (WA)

The selection process based on the criteria defined in Table 3 results in a narrowing of leadership styles from 17 to ten. The detailed literature search is shown in Appendix I. Specifically, the leadership styles Servant Leadership, Transformational Leadership, Shared Leadership, Emergent Leadership, Visionary Leadership,

Situational Leadership, e-Leadership, Complexity Leadership, and Distributed Leadership fulfill the defined selection criteria (see Table 4).

Table 4: Selection of Leadership Theories

Leadership Theories	WS	BZ	WA	Criteria fulfilled (Yes/No)
Servant Leadership (SEL)	x	x	x	Yes
Transformational Leadership (TFL)	x	x	x	Yes
Shared Leadership (SHL)	x	x	x	Yes
Emergent Leadership (EML)	x	x	x	Yes
Visionary Leadership (VIL)	x	x	x	Yes
Situational Leadership (SIL)	x	x	x	Yes
Promise-based Leadership (PBL)	x	x	-	No
The new deal to the top (NDT)	x	x	-	No
Executive as a coach (EXC)	x	x	-	No
Transactional Leadership (TRL)	x	-	x	No
e-Leadership (ELE)	x	x	x	Yes
Digital Leadership (DGL)	x	x	-	No
The connected Leader (TCL)	x	x	-	No
Complexity Leadership (COL)	x	x	x	Yes
Distributed Leadership (DIL)	x	x	x	Yes

In a next step, the analysis is limited to the relevant leadership styles. It is assumed that the leadership styles most frequently found in the scientific databases are the most relevant in the context of agile leadership. Specifically, the leadership styles Servant Leadership, Transformational Leadership, Shared Leadership, Emergent Leadership and Visionary Leadership are classified as relevant agile leadership styles based on the frequency of the search terms found. The online research shows a significantly lower number of search results for the styles Situational Leadership, e-Leadership, Complexity Leadership and Distributed Leadership. Table 5 gives an overview of the definitions of the selected leadership styles. In the next step, these are examined using a structured criteria catalog to identify possible differences and similarities.

Table 5: Definition Leadership Styles

Servant Leadership (SEL)	The core of SEL is that the leader does not view leadership as a position or status, but as an opportunity to serve others (Greenleaf, 1970, p. 7;Winston, 2003, p. 4; Smith, Montagno, & Kuzmenko, 2004, p. 81).
Transformational Leadership (TFL)	A transformational leader takes targeted actions to provide followers with an integrated understanding of what needs to be achieved. Transformational leaders increase self-confidence and intrinsic motivation in terms of performance (Bass 1985; Wang, Courtright, & Colbert, 2011, p.224)
Emergent Leadership (EML)	Emergent leadership is detached from the organizational hierarchy (Bolden, 2004, p. 12). Thus, individuals at all levels in the organisation and in all roles can exert leadership influence on their colleagues and thus influence the overall direction of the organisation (Bolden, 2004, p. 13).
Shared Leadership (SHL)	Shared leadership does not embody the leader in a single person, but is distributed among the team members (Moe, Dingsøyr, & Kvangardsnes, 2009, p. 1-2). Central to this is interaction between team members and mutual influence and the pursuit of common goals. This should ultimately lead to improved team and company performance (Carson, Tesluk, & Marrone, 2007, p. 1217ff.).
Visionary Leadership (VIL)	In the course of Visionary Leadership, a picture of the desired organizational state is effectively described and communicated (Bennis & Nanus, 1987; Tichy & Devann, 1986) a picture of a desired organizational state (Bass, 1987, p. 57), which serves to enable the followers to implement the vision (Sashkin, 1987; Srivastva, 1983; Conger & Kanugu, 1987) It has the ability to transform a traditional organization by shaping a desired future and motivating others to take personal responsibility for performance (Nwankwo, & Richardson, 1996, p. 45).

3.2 Analysis based on a catalogue of criteria

In the context of this chapter, the leadership styles are examined using a structured catalogue of criteria.

Leadership Ability - Leadership Ability in the areas of leading skills and dedication is relatively balanced. The leadership styles analyzed are particularly well documented in the area of leading skills. In the majority of cases, this shows the high relevance of interpersonal skills and the competence to build top performance teams. In the Dedication sub-sector, the importance of responsibility and dedication to professional obligations is evident across all styles. On the other hand, a divided view on intrinsic motivation can be observed. Self-promotion is mainly found in the theory of Servant Leadership, whereas this aspect of Leadership Ability is completely missing in Emergent Leadership, Shared Leadership and Transformational Leadership. In principle, there is hardly any overlap in this area. The design of self-promotion therefore differs greatly in terms of scope and content for each leadership style. In summary, however, it can be said that Leadership Ability can be observed comprehensively in all styles. Above all, Servant Leadership, which with eleven criteria fulfils a high proportion of the total 18 aspects.

Social Skills: Working together is considered relevant in all leadership styles except Visionary Leadership. In this context, the importance of cooperation and building personal relationships is particularly evident. In particular, the leadership style Shared Leadership deals with different areas of cooperation (Working together). The most relevant sub-area in terms of content is value orientation, which is addressed by all five leadership styles. The majority of the styles see the importance of inspiring employees and communicating a shared vision transparently. In summary, it can be said that the styles deal with Social Skills with varying degrees of intensity. However, most styles comprehensively document aspects of social skills in terms of content. Only Visionary Leadership is an exception.

Learning Agility: Learning Agility is addressed in varying degrees of detail and comprehensively. In particular, the leadership styles Shared Leadership, Transformational Leadership and Servant Leadership deal in detail with the agility of learning behavior (Learning Agility). The subarea Willingness to learn shows the high relevance of learning and supporting others in the learning process. But also,

the development of a learning culture is discussed in the theory of Servant Leadership and Transformational Leadership. The subarea Emotional intelligence is considered relevant by the majority of leadership styles. Especially the development of skills to cope with stress and ambiguity is considered important. The Adaptive / Perseverance subarea receives the most attention. All leadership theories deal with this area to varying degrees. The frequent mention of adapting the communication style is striking. There is hardly any overlap in the remaining criteria in this sub-area. In summary, a rather split picture can be observed. On the one hand, Visionary Leadership and Emergent Leadership, which only deal with one or two aspects of the category, and on the other hand Servant Leadership, Transformational Leadership and Shared Leadership, which address criteria for all areas.

Analytical Skills: Analytical Skills is dealt with in varying degrees of intensity. It is noticeable that the distribution is rather contrary to the other categories. Specifically, Servant Leadership covers very few aspects of content, whereas Visionary Leadership goes into great detail on the criteria listed. A look at the Strategic Insight section reveals a split picture. Both Visionary Leadership and Shared Leadership cover a large proportion of the aspects, while the other styles cover little or no criteria. In addition, the subarea of decision making is highly relevant in the theories of transformational leadership and visionary leadership. Especially the ability to make decisions and to enable others to make decisions is considered relevant by the majority of the styles. The problem solving part is covered by all styles except Servant Leadership. Here the importance of building problem solving skills is particularly evident. The Foster mutual dependence section shows a similar picture. In the theories of Visionary Leadership, Emergent Leadership and Shared Leadership you will find theories on the corresponding criteria. The advantages of overlapping skills and competencies are considered to be particularly crucial. Results orientation is particularly dealt with in the theories of Visionary Leadership and Shared Leadership.

In summary, the analytical aspect of leadership (Analytical Skills) is represented very differently in the theories. The theories on Visionary Leadership and Shared Leadership in particular deal intensively with this aspect. Transformational Leadership, Emergent Leadership and Servant Leadership, on the other hand, deal with the contents to a significantly smaller extent.

4 Conclusion, Limitation and Further Research

What has already been hinted at in theory is also evident in the study. The theory shows that original forms of management, especially in the context of traditional hierarchical corporate structures, were primarily process-oriented. In contrast, today's more modern management styles focus primarily on people. The personality traits of the leader are particularly important. This is also shown by the analysis carried out. Agile Leadership is a broadly based term, which includes a multitude of factors, which are particularly in the area of character traits. This can be derived from the scope and content of the consolidated catalogue of criteria, which is very comprehensive with four categories, sixteen subcategories and 71 parameters. Nevertheless, it is possible to define the main focus of this subject area in terms of content. The four criteria Leadership Ability, Social Skills, Learning Agility and Analytical Skills, which are more personal factors, indicate the main focus of the leadership theories analysed.

A similar picture in connection with the observed scope can be seen in the selection of the styles to be examined. Databases show a large number of terms in the context of agile leadership, with only a limited number of five theories showing a corresponding relevance due to the frequency of the search results. In terms of content, however, no clear conclusion can be drawn

Within the broad spectrum of the term agile leadership, the five styles examined position themselves very differently (in terms of content and scope). It can be stated, however, that the styles are neither completely congruent nor completely independent of each other. In summary, the study shows transparently that although there is some overlap between different agile leadership styles, the theories differ significantly from each other when viewed holistically.

The catalogue of criteria used is based on a limited number of scientific papers on the topic of agile leadership, whereas there is a large number of publications on the topic. Nevertheless, the chosen number and selection of publications is considered meaningful, as the project team believes that they provide broad support for the term agile leadership. It should also be mentioned that only a limited number of leadership styles were examined. Furthermore, no conclusive objectivity can be guaranteed both for the selection of the individual criteria and for the clarification

of the agreement in papers. For both the selection process and the analysis process, a certain degree of subjectivity cannot be avoided within the scope of this work.

The analysis carried out and the knowledge gained will serve as a basis for further research in the field of agile leadership. In the literature, there is a need for further research to define the concept of agile leadership. It would also be of great benefit, especially for management practice, to investigate in which corporate context and under which conditions, which of the identified agile leadership styles should be used. Further interesting insights would also be provided by researching the dependencies of the leadership theories analyzed on factors such as culture, geographical origin, authors and temporal development.

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SMART CITY DEVELOPMENT WITH DIGITAL TWIN TECHNOLOGY

MERVI HÄMÄLÄINEN[1]

[1] University of Vaasa, School of Marketing and Communication, Vaasa, Finland, e-mail: Mervi.hamalainen@uwasa.fi

Abstract Growing urban areas are major consumers of natural resources, energy and raw materials. Understanding cities´ urban metabolism is salient when developing sustainable and resilient cities. This paper addresses concepts of smart city and digital twin technology as means to foster more sustainable urban development. Smart city has globally been well adopted concept in urban development. With smart city development cities aim to optimize overall performance of the city, its infrastructures, processes and services, but also to improve socio-economic well-being. Dynamic digital twins are constituted to form real-time connectivity between virtual and physical objects. Digital twin combines virtual objects to its physical counterparts. This conceptual paper provides additionally examples from dynamic digital twin platforms and digital twin of Helsinki, Finland.

Keywords: smart city, digital twin, urban development, technology, bled e-conference.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.20
ISBN 978-961-286-362-3

1 Introduction

According to UNEP (2013) cities globally are responsible of over 75 percent of the world´s energy and material flows and consumption. Cities thus have salient role in controlling resource and material intensity. It is emphasised that understanding of cities´ urban metabolism is fundamental when developing more sustainable cities and communities (Kennedy, Pincetl & Bunje, 2011). Urban metabolism refers to the production and usage of diverse natural and non-renewable materials like water, energy, food and waste in urban area (Gandy, 2004; Kennedy, Pincetl & Bunje, 2011). With urban metabolism it is also referred to the process of material use in the city, import and export of material flows, recycling, waste management (Bahers, Barles & Durand, 2019) and principles of circular economy.

Cities globally benefit advanced digital technologies to reach their sustainability goals. Digital technologies like sensor and Internet-of-Things (IoT) technologies, artificial intelligence (AI) and data analytic solutions are used to improve energy and resource efficiency and waste management within the city. Investing in digital technologies cities aim to strengthen overall monitoring and governance of the city. Novel digital technologies also enhance the development of the cities critical functions and infrastructures like energy, water and transportation. With novel digital technologies, the city may synchronise its processes and attract citizens to attend urban development activities. By doing so cities make city operations more transparent and less bureaucratic for the citizens. (Gabrys, 2014; Lea et al., 2015; Olivares, Royo & Ortiz, 2013; Sánchez et al., 2013; Zanella et al., 2014.)

This article addresses the concepts of smart city and digital twin technology as means to overcome cities´ sustainability and urban metabolism issues. Smart city denotes the usage of digital technologies like IoT, big data and (AI) to improve socio-economic and environmental outcomes of the city (ITU-T Focus group, 2015; ISO, 2013). Digital twin technology illustrates both virtual and physical representation of an object. With IoT and sensor technologies, it is possible to form dynamic connectivity between virtual replica and its physical counterpart. Dynamic connectivity of digital twin enables combining data and observing digital twin in its real and virtual world. (Enders & Hoßbach, 2019.) Furthermore, the article brings out an example of digital twin of Kalasatama district in Finland and presents commercial dynamic digital twin platforms in the smart city context. This article is

organized as follows: after the introduction in Section 1, Section 2 summarizes article´s data sources. Sections 3 and 4 review the concepts of smart city and digital twin. Section 5 covers digital twin platforms in smart city development. Section 6 discusses digital twin of Kalasatama smart city district. Sections 7 summarizes the work and section 8 concludes the paper.

2 Methodology

The theoretical background is based on literature of smart city and digital twin technology. Data from the digital twin of Kalasatama district was collected from written final project report available at city of Helsinki website. Materials for dynamic digital twin platforms were collected from public data sources like company´s product presentations and websites. Further, data was acquired by interviewing representatives of commercial digital twin platform providers Cityzenith and Platform of Trust companies.

Table 1: Data sources

Subject	Source
Theoretical background	Existing literature
Digital twin of Kalasatama district	Kira-digi project – final written project report received from Helsinki city website
Smart World Pro platform by Cityzenith	Phone interview with Business Development Manager, 3.2.2020 Product presentation materials Company website
Platform of Trust	Onsite interview with Chief Impact Officer 5.2.2020 Company website
Open Cities planner platform by Agency 9 & Bentley	Company website

3 Smart city

Smart city concept has played significant role in cities´ digital transformation. Simplistic and narrow definition of the smart city means that city utilizes modern digital technologies to improve city services, infrastructure and quality of citizens' lives. However, a broader definition complement socio-technical perspective and observes smart city from economic and environmental perspectives. For instance, Caragliu, Del Bo and Nijkamp (2011) consider city is smart "when investments in human and social capital and traditional (transport) and modern ICT communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory government". In European settings, European Commission considers smart city as "a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies and that "a smart city goes beyond the use of information and communication technologies (ICT) for better resource use and less emissions" (European Commission).

In Europe European Commission has created a specific policy to foster urban development with digital technologies. To strengthen smart city initiatives, European Union has directed investments towards smart city development and has offered funding for information and digital technologies to renew and upgrade power grids, buildings, public transportation and waste management systems in European cities. European cities have actively responded to European Union´s call and established partnerships with industries and academia to make necessary changes in cities. As a result, new models and solutions for more sustainable urban development have emerged. (European Commission.)

4 Digital twin

Digital twin has taken foothold in product and manufacturing design, but recently also other industries like aerospace, automation, marine, healthcare and energy sectors have benefited digital twin technology (Enders & Hoßbach, 2019). Reason for more widespread utilization of digital twin technology is that virtual simulation technologies have evolved along with advance digital technologies like data collection and virtual manufacturing technologies (Zheng, Yang, Chen, 2019). Foundations for digital twin lays in computer aided design (CAD), which enables

static three-dimensional (3D) product design and representation (Grieves & Vickers, 2017). Whereas CAD designed product is static digital twin provides more dynamic representation of 3D designed product or solution. It is suggested that in the most optimal cases digital twin represents the same features and provides the same information as its physical counterpart. (Grieves & Vickers, 2017.) Most commonly digital twin is utilized for simulation, monitoring and control purposes (Enders & Hoßbach, 2019), but also to calculate and regulate the system status and processes (Zheng, Yang, Chen, 2019). As digital twin is a simulation of the system itself (Negri, Fumagalli & Macchi, 2017), it extends possibilities to explore e.g. behaviour of 3D designed solution in virtual space. Digital twin enables also to explore and test how physical forces influence on designed object. (Enders & Hoßbach, 2019; Grieves & Vickers, 2017.) For monitoring purposes, digital twin enables to represent and interpret properties and current state of a physical and virtual object. Novel digital solutions like IoT and high-speed connections like 5G extend real-time monitoring and synchronizing capabilities of virtual and physical objects. Control aspect covers applications, where digital twin directly influences products or manufacturing assets and enables controlling physical objects remotely in real-time. (Negri, Fumagalli & Macchi, 2017; Enders & Hoßbach, 2019.

One very essential part of the digital twin is the connectivity of the virtual and physical counterparts (Enders & Hoßbach, 2019). One-directional connection refers to a physical object, which has one-way connectivity to its virtual counterpart (Enders & Hoßbach, 2019). One-directional data flow and connection is also referred as digital shadow (Kritzinger et al., 2018; Zheng, Yang, Chen, 2019). Digital shadow refers as "a change in state of the physical object leads to a change of state in the digital object, but not vice versa" (Kritzinger et al., 2018). Bi-directional connection refers to a digital twin that forms mutual connection between physical and its virtual object. Bi-directional connectivity is built on distributed computing devices and data systems that utilize data and real-time connectivity. Bi-directional connectivity enables digital twin to control its physical counterpart without human intervention. (Enders & Hoßbach, 2019; Zheng, Yang, Chen, 2019.) Bi-directional connection consists of different layers e.g. multiple data sources, physical and virtual devices, sensors, data connection and cloud-based environment (Redelinghuys, Kruger & Basson, 2019).

4.1. Benefits of the digital twin

It is argued digital twin is a key enabler of digital transformation (Kritzinger et al. 2018) and organizations may receive multiple benefits from digital twin technology. Compared to static 3D models, real-time connectivity and data from both virtual and physical objects enables real-time system product design, simulation and testing with less time and expenses. Further real-time virtual representation of physical object minimizes design errors resulting less failures of physical system in manufacturing or in actual use. (Grieves & Vickers, 2017.) Digital twin is also prominent technology to bridge multi-stakeholder teams. Real-time virtual simulation environment extends accessibility of diverse stakeholder groups like global product designers, research and development teams, final users and customers to collaborate jointly in virtual environment. With digital twin technology vendors may easily educate and train stakeholders in value networks and provide more extensive customer support for clients. (Alaei et al. 2018.) As virtual and physical objects together with data form the core of the digital twin (Tao et al., 2017; Zheng, Yang, Chen, 2019) digital twin is notable technology to assist organizations with decision making. Real-time connectivity of virtual and physical objects allow organizations´ to detect anomalies and make analysis based on the data received from both virtual and physical objects. Real-time virtual representation of physical systems extends possibilities to make predictions of the conditions of the complex physical systems allowing organization to consider alternative scenarios for the probable outcomes of the cyber-physical system. (Grieves & Vickers, 2017; Negri, Fumagalli & Macchi, 2017.)

5 Smart city digital twin platforms

Cloud-based digital platforms have been commonplace when developing and integrating IoT elements like connected devices, gateways and applications to digital platform. Cloud-based platforms enable to manage IoT service development, distribution and ecosystems evolution. (Mazhelis & Tyrväinen, 2014.) In the smart city context digital twin platforms are established to integrate both virtual and real-world elements of the smart city. Platforms like Smart World Pro, Open Cities planner and Platform of Trust are examples of cloud platforms that integrate data from diverse smart city data sources. Smart World Pro aggregates visual 3D models of the city, building and geospatial information, IoT devices and other data sets and

simultaneously create virtual replica of the real-world smart city entities. The dashboard feature of the Smart World Pro collects smart city projects under project portfolio and provides visual view for the smart city entities. (Agency9 & Bentley, Cityzenith, Platform of Trust, 2020.)

Open Cities planner platform enables smart city developers to integrate data sets like 3D models, images, documents geographic and vector data. Open Cities planner works in any web browser and is scalable augmenting possibilities to outline and explore city from street level to a broader city level perspectives. Platform of Trust is a platform that integrates data from diverse data sources and providers. With harmonized data Platform of Trust improves data interoperability and trust among data providers. Platform is scalable and enable data integration from small to large-scale needs. (Agency9 & Bentley, Platform of Trust, 2020.)

5.1. Stakeholder integration on digital twin platforms

Smart city digital twin platforms are virtual meeting points for multi-stakeholder groups within the smart city. The Smart World Pro and Open Cities planner platforms enable smart city developer or project owner easily to integrate heterogeneous stakeholders like architects, engineers, constructors, property owners and managers into the platform. The smart city digital twin platforms thus augment the co-development and collaboration among the smart city stakeholders. As an example, the stakeholders like architectures, urban designers and engineers may easily simulate and test different scenarios and evaluate how changes in certain city parameters like speed limits influence air quality, noise levels and people flow in certain area (Ruohomäki et al., 2018). Digital twin and visual 3D environments also assist integrating citizens to urban development. The Open Cities planner platform has been an environment for local citizens to share their knowledge and expertise. It is also used to crowdsource idea generation within the city. From the city governance perspective, the virtual replica of the city and digital twin platforms improve the governance and outcome of smart city development initiatives. (KIRA-digi project report, 2019.)

6 Smart city development with digital twin – Case Kalasatama digital twin

3D modelling techniques are commonplace in modern urban design and development. 3D modelling tools are utilized e.g. in transportation, land use, town and regional planning. In the smart city development novel digital technologies like Internet-of-Things (IoT), data analytics and artificial intelligent solutions are exploited in diverse city verticals to support smart city development. Dynamic digital technologies together with static 3D modelling and digital twin technologies extend city to understand its spatiotemporal fluctuation (Mohammadi & Taylor, 2017) and improve observing and testing smart city scenarios in multiple levels. Digital twin also supports co-creation of smart city with diverse stakeholders. (Ruohomäki, 2018.)

The capital city of Finland, Helsinki, executed its first urban digital twin initiative in Kalasatama district. Kalasatama district is a strategic smart city development area in Helsinki city. Primary objectives of Kalasatama digital twin initiative were to produce high quality 3D models and publish them as open data for public. Other objectives concerned integrating digital twin model to existing urban development projects and experimenting new digital technologies with high quality 3D models. Kalasatama digital twin initiative aimed also to exploit digital twin in the future design of the city processes and services. (KIRA-digi project report, 2019.)

The first digital twin project objective was actualized by creating and using semantic city data models and reality mesh models of the Kalasatama district. For semantic city data models, a global CityGML standard was applied. CityGML is an open standardized data model to store and exchange virtual 3D city models (Open Geospatial Consortium). For reality mesh models, data from existing aerial photos, point cloud datasets and laser scanning was utilized. Finally, both reality mesh models and semantic city data models were released as open data for public use. By doing so, the city seeks especially to attract construction and real estate operators to benefit digital twin of Kalasatama. (KIRA-digi project report, 2019.) Long-term vision is to support city processes and overall local service development, innovation and businesses in the region with city level digital twin virtual platform (Helsinki city, 2019).

Integrating Kalasatama digital twin to other Smart Kalasatama projects complement the overall development of the region. A specific application called "Open Cities planner" was developed to integrate other Smart Kalasatama projects into virtual digital twin environment. Open Cities planner enabled to visualize, test and experiment the other Smart Kalasatama initiatives in virtual environment before final execution. Kalasatama digital twin was also beneficial for implementing simulations like wind and solar simulations in Kalasatama district. (KIRA-digi project report, 2019.)

6.1. Digital twin restrictions in smart city settings

Creating virtual replica of the smart city contain some restrictions. Visual 3D models and data from other smart city sources engender large amount of data, which set demands for computing power. In the case of Kalasatama digital twin project, generating the 3D mesh model required computers with high computing capacity as 3D mesh model contained large number of data from aerial photos, point cloud datasets and laser scanning. The 3D mesh model was finally created by ContextCapture application. (KIRA-digi project report, 2019.) Additionally, the study by Ruohomäki et al. (2018) show that generating high quality 3D models may be laborious as the data used for 3D model may need manual cleaning and preparation.

7 Discussion

Ubiquitous digital infrastructures with fast telecommunication connections, IoT and sensor technologies have enabled real-time data collection from real-world entities. Concept of digital twin is used to represent and illustrate how dynamic virtual object operates with its physical real-world counterpart and vice versa. Digital twin technology is well adopted in manufacturing industry, but technology has taken foothold also in other industries like aerospace, automation and energy.

In the smart city settings, digital twin platforms are emerging to assist smart city planning and development. Digital twin platforms enable to aggregate static city data sets like visual 3D models with dynamic real-time city data. This extends urban developers´ possibilities to outline the city, explore and experiment diverse scenarios in virtual environment before final implementation. In the case of Kalasatama

district, the purpose of Kalasatama digital twin was to observe whole lifecycle of district´s built urban environment, but also to provide a platform for smart city design and testing, application and service development. As an example, the developers used Kalasatama digital twin to simulate and observe how changing weather conditions like wind and solar light impact on district and its built environment over the time. Urban developers utilized both historical and actual data when implementing the simulations in Kalasatama. Based on the results urban designers and researchers´ were able to evaluate e.g. solar energy potential in the area and analyse how storm winds will influence area´s buildings and their surroundings.

Digital twin platform allows low threshold access for smart city stakeholder collaboration. In virtual digital twin environment stakeholders may easily interact and participate urban development process, which enhance transparency and trust among the stakeholders. In Kalasatama district dynamic digital twin platform enabled to bring together diverse smart city stakeholders like urban designers, constructors, city authorities and citizens to change ideas, explore and experiment alternative scenarios and find optimal solutions for real-world city development projects. As an example dynamic digital twin extended stakeholders to consider e.g. impacts and risks of climate change like draught, storm winds, sunlight emissions and floods on current and future built urban environments. (KIRA-digi project report, 2019; Ruohomäki et al., 2018.)

Considering the urban metabolism, the usage and flow of natural and non-renewable materials, evidence of digital twin´s applicability and benefits in urban metabolism design need further research. Dynamic digital twin may be a valid technology to optimize urban metabolism and to explore alternative choices for raw material flows and consumption in the city. With digital twin the city may develop more resource intensive solutions e.g. in the areas of circular economy and industrial symbiosis. In optimal case, digital twin technology may assist city developers to design industrial and city ecosystems so that less raw materials are used, and no waste is produced.

Dynamic city level digital twin is thus a viable tool for urban planning in changing circumstances. However, dynamic digital twins with visual 3D models require high computing and data processing capacities. Generating high quality dynamic digital twins may also need manual cleaning and preparation of data, which may be

laborious and time consuming. These factors may hinder digital twin technology´s usage and implementation is smart city development.

8 Conclusion

Smart city development is prominent concept to manage sustainability matters within the cities. Advanced digital technologies like sensor and IoT technologies, data analytics and AI are viable tools to assist cities in their efforts to enhance urban metabolism and the design of more sustainable cities. This article addressed, in addition to the concept of smart city, a digital twin technology as a mean to foster holistic urban development. Dynamic digital twin opens possibilities to explore city´s infrastructures and processes in virtual environment. Urban designers may analyse e.g. changing climate parameters´ impacts on the city, build and simulate probable scenarios under diverse circumstances. Dynamic digital twin might also assist urban designers to optimize urban metabolism of the city and shed light on more efficient and intensive resource and material use in cities. Further research is needed to investigate digital twin technology´s applicability for the design of circular economy and urban metabolism in the cities.

This paper also addressed digital twin platforms for multi-stakeholder collaboration. Dynamic digital twin platforms are feasible environments to combine heterogeneous urban stakeholders like architectures, urban designers, constructors and citizens. Digital twin platforms strengthen transparency and communication, but also trust among diverse urban stakeholder groups. Digital twin platforms are low threshold environments to design and analyse probable scenarios and evaluate risks caused by factors like climate change. With digital twin technology, cities may optimize and improve overall performance of the city, its infrastructures, processes and services, but also socio-economic well-being.

This conceptual paper contained data from prior literature of smart cities and digital twin technology. Project report of Kalasatama digital twin and interviews from smart city digital twin platform providers complemented the study. Applying digital twin solution to specific smart city domain would enrich the future study and extend understanding of the digital twin technology´s relevancy in smart city settings.

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PERSONALIZING THE LEARNING PROCESS WITH WIHI

JUHA LINDSTEDT[1], RAINE KAUPPINEN[2] &
ALTTI LAGSTEDT[2]

[1] Haaga-Helia University of Applied Sciences, Business Programmes, Helsinki, Finland,
e-mail: juha.lindstedt@haaga-helia.fi
[2] Haaga-Helia University of Applied Sciences, Digital Business, Helsinki, Finland,
e-mail: raine.kauppinen@haaga-helia.fi, altti.lagstedt@haaga-helia.fi

Abstract Societies are changing rapidly because of automation and digitalization, but local and global business environments are also becoming more volatile. Changing societies also place requirements on education: the number of atypical learners is growing all the time, and lifelong careers have been changed to lifelong learning. Traditional education approaches do not support part-time learners or lifelong learning; personalizing the learning process for every student separately is too laborious. In this paper, we study a flexible, personalized learning approach and an information system (Wihi) to support it. Wihi is a thesis management tool for students to plan and schedule their theses and for the thesis supervisor to centrally monitor the progress of different theses. In addition, it allows curriculum management to follow the whole thesis situation. Although Wihi was developed for a specific need, the personalized learning assumptions behind it are also applicable in other education cases.

Keywords: digitalization, personalized learning, digitalized teaching processes, lifelong learning, thesis.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.21
ISBN 978-961-286-362-3

1 Introduction

It has been estimated that, due to digitalization and automation, a remarkable share of jobs is vanishing (Wike & Stokes 2018). At the same time, for the same reasons, new jobs are emerging and new skills are needed. In addition, today's economy is more volatile than it used to be and changes anywhere in the world are affecting societies faster and heavier than before. The only constant in the world is change.

This means that, to adapt to the change, individuals must be ready to study new skills frequently. When digitalization and automation remove jobs that are monotonous and easy to automate, the new ones are much more complicated and require deeper learning from employees (Wilson, Daugherty, & Morini-Bianzino 2017). The education that was enough for a good job a couple decades ago will not be enough for today's work environment. Lifetime careers are no longer a presumption. More often, individuals have to learn several different professions during their lifetimes. In addition, it seems that the Z generation is not even interested in lifelong careers; they want to have change and new challenges.

Thus, there is a need for personalized learning solutions. Students should be able to plan the main targets, necessary skills, and learning objectives of the studies, as well as the stages and schedules of the study, independently from the semester term or period. In some situations, the study target can be graduation, but often the same students just need to learn some new skills to outperform in their profession; the emphasis may change rapidly. Schools and universities should not restrict the students. Full-time, part-time, time-independent and continuous learning should be possible for all students.

However, lecturers' and professors' working time is not enough to follow and guide each separate student's objectives, selections, and progress. Likewise, their tools do not support personalized teaching: student registers and e-learning platforms are built on the idea of courses and curriculum (see e.g. Dirin & Laine 2018), and other tools like Excel are too generic and not interactive at all.

New kind of flexibility was the main target when Wihi, a new system for supervising thesis projects, was developed in Haaga-Helia UAS (University of Applied Sciences). Before Wihi, the thesis process was managed with spreadsheets, emails, and documents submitted to e-learning platforms such as Moodle and Blackboard from time to time. Since students conduct different kinds of development and research projects for their theses, they all have separate plans, tasks, and schedules. With the previous systems, it was difficult for teachers to follow the progression of students, for students to get comments, feedback, and guidance on time, and for thesis coordinators and other management to see what the whole situation is: how many students will graduate and whether there is a need for special arrangements (supporting courses, etc.). Thus, the idea was to create a thesis specific IS (Wihi) providing support for personalized thesis projects so that they still follow the thesis process and its guidelines of Haaga-Helia UAS.

The challenges of the thesis process have been recognized, and some related work has been done in both the areas of quality improvement and IS support (Aghaee 2015; Karunaratne 2018; Lagstedt 2015). A thesis process support system similar to Wihi is SciPro and Hansen and Hansson (2015) have studied student-supervisor interaction with it. But, previous works do not focus on personalization aspects.

To find out how well the developed IS (Wihi) answered the personalized learning needs of thesis process, the following research questions were formulated: **RQ 1:** *How and to which extent did the IS innovation project (Wihi) resolve the problems that occurred in the old thesis process supporting personalization?* **RQ 2:** *Which way the new IS was able to enhance the process handling and understanding from students' and teachers' perspective?*

2 Theoretical background

Teachers may use new technologies only as a substitute manual tasks, or they can take totally new digitalized processes in use (Jude, Kajura, & Birevu 2014). As personalized learning requires the latter, more challenging approach, it is important to evaluate what aspects affect students' and teachers' actions.

A thesis process is an example of a problem-solving project where student gains better comprehension of the chosen topic. Here, we follow Pritchard and Woollard's (2010, 89) definition of constructivist learning theory: a learner constructs one's own understanding by selecting and transforming information (past and present) in order to gain new personal knowledge and understanding.

2.1 The nature of learning processes

Especially higher-level students construct their own study paths. Alternatives are available from both content and pedagogical approaches. A university itself normally defines the nature and scope of the thesis. The university sets, for example, reporting standards and the format of the thesis. Otherwise, a student has a lot of freedom to design and execute the process, and a teacher has rather a supporting than an advisory role. Situation like this can be classified as Mezirow's "communicative learning" (Mezirow 2012, 77), which in turn is based on Habermas' categorization of instrumental and communicative learning.

2.2 Motivation

In Self-Determination Theory (SDT) motivation is distinguished between two categories; *intrinsic* and *extrinsic* (Ryan & Deci 2000, 55). A thesis is as an example of extrinsic motivation, especially a commissioned one, since it enables graduation as an external reward. However, sometimes the thesis project may halt for different reasons, not always because of the student's own. It is much easier to continue if also the intrinsic motivation is high; Ryan and Deci (ibid., 55) remind that intrinsic motivation leads to higher level of learning and creativity. Naturally, high self-discipline or commitment and a strong routine may compensate for the lack of motivation, but with most people, the inner motivation is the driving force.

Keller's (1987) ARCS model of instructional design can be used to operationalize motivation-related ideas. In learning, the first condition is *attention* (ibid., 3). Attention is built in the thesis process: students can choose topics from the area of their own interest. The second attribute in the model is *relevance* (ibid., 3). This is also covered in a thesis process both because of the topic selection and because of the importance of the thesis for the degree studies. When attention and relevance are more like prerequisites of motivation, it is also important to sustain a high level of

motivation, especially in a long-lasting project such as the thesis. *Confidence* (ibid., 3) is higher in some people who have a higher likelihood of success. This feature, related to self-esteem, can be supported by proper counseling and feedback (see section 2.4). The fourth component, *satisfaction*, has its origin in behavioristic reinforcement (ibid., 3). Successfully completed tasks or phases and positive feedback from the supervisor increase satisfaction.

2.3 From Autoregulation to Self-directedness

In relation to motivation theory, self-regulation or autoregulation, as e.g. Leontiev prefers it (Leontiev 2012, 94), explains the mechanisms that regulate human behaviour. In the context of pedagogy, this can be formulated as self-directedness. According to Breed (2016, 3), self-directed learning (SDL) requires student to figure out the learning needs and strategies to learn in order to meet his/her goals. Breed continues that some other researchers (e.g. Guglielmino; Brockett and Hiemstra) put more weight on the learners' characteristics. This leads the discussion back to self-determination and intrinsic motivation (see section 2.2), as well as, problem-based learning, which is in line with the nature of thesis process.

2.4 Feedback

Even if behavioural learning theories are mostly superseded by cognitive psychology and constructivism, the reinforcement appears in motivation theories (e.g. Keller 1987). Immediate feedback is the most efficient. The challenge of the thesis is that the feedback is often directed to faults and deficits in the report, which sets a need for constructive feedback that does not demotivate the student to continue. Based on the feedback of graduating students (The Ministry of Education and Culture and the Finnish National Agency for Education 2020), some students feel that they do not get constructive feedback or that feedback is given too late, when the project is in its final stage, so not much can be done if the problems are fundamental.

The students' behaviour may vary from a type of student who is highly independent with high self-esteem and is, therefore, not interested in feedback. Some may even get irritated if a supervisor is too keen on giving feedback (see also Keller 1987, 6). Illeris (2009, 16) even mentions mental resistance, which may block or distort learning. In a thesis work, a student may have already put all the effort into the

report, and feedback that would require changes may be too much to handle. The other extreme are students who are unsure about their decisions, so, they continuously want feedback on all the details. Without the requested response from the supervisor, a student may halt the process. Therefore, it is vital for a supervisor to manage the feedback and keep it at optimal level.

2.5 The role of the teacher

The roles of the thesis supervisor and the student could be compared to the apprenticeship model. In this setting, the knowledge and skills are transferred from a master/supervisor to an apprentice/student (Pritchard & Woollard 2010, 16-17).

Thanks to the Internet and modern libraries, the students have access to the same sources of information as teachers. However, in the thesis process, there is still a need for traditional tutoring in order to gain intellectual and cognitive growth, as Lev Vygotsky would express it (Pritchard & Woollard 2010, 14). This is easy for a professional teacher, but the systematic follow-up of every thesis project (each with their own schedules) is challenging. Different spreadsheets and calendar applications are needed to deal with the situation. This is especially challenging, when one thesis supervisor may get, for example, a group of ten new students twice a year to be supervised, and simultaneously, earlier students may have projects pending in different phases. In this situation, e-mail communication is scattered in the supervisor's mailbox, with intermediate versions either as attachments in emails or saved in supervisors' folders. In these kind of situations some students needing more attention go easily unnoticed, which might lead to a delayed process or even to the students' dropping off their projects or their studies altogether.

3 Methods

3.1 Case: Thesis Process and Wihi

The thesis process was digitalized, and Wihi was developed applying an expert oriented digitalization model EXOD (Kauppinen, Lagstedt, & Lindstedt 2019). The EXOD model has four phases: initiation, process and IS re-engineering, IS development and stabilization. Data used here is from the first three phases.

In its initiation (before 2014), Haaga-Helia UAS described its core processes, revealing that the thesis process was one of the most complicated. In the second phase, the process was re-engineered during 2014–2017. In the third phase, Wihi was developed during 2016–2019, and changes to the learning process were implemented and communicated. After the fall 2018 test period, Wihi was launched into full use in January 2019 starting the stabilization phase.

3.2 Research Method

In the case study research, we followed the recommendations of Yin (2009). We extensively used the four data collection sources (documentation, archival records, participant observation, and interviews) that Yin (2009) recommends. Since one of the researchers was responsible for the thesis process development and another for the development of the IS (Wihi) supporting it, we had access to both the process and IS development documentation. We also utilized (for both RQ 1 and 2) Wihi's logs and registers (over 400 cases available) as supporting data to understand the actual IS usage. As thesis coordinators and supervisors, we also used (for RQ 2) Wihi to make participant observations. Eight thesis supervisors and six students were interviewed in May 2019 representing the active user perspective in both on applying the personalized learning process and in using the IS (Wihi). In the analysis, the main emphasis was on the interviews (n = 14, the number of interview questions was 20 consisting of 3 background variables and 17 research variables). The other sources, such as the minutes of the university-level thesis coordinators' meetings, feedback that was converted to prioritize design plans, task force (core designer group) meeting summaries, and initiatives from staff, were considered complementary data (for RQ 1).

During interviews the example of Dahlberg, Hokkanen and Newman (2016), was followed; questions were presented onscreen, either face-to-face or via a video call and answers were typed and presented right away. This allowed the interviewees to validate the typed answers immediately. The method allowed us to easily assess the saturation after each interview. The content analysis was done by using Excel.

4 Results

4.1 Re-engineered learning process in Wihi

The re-engineered thesis process has seven phases, from the approval of the topic to the completion of the thesis process (Figure 1). The student-supervisor–oriented learning process is most active from project planning and scheduling to the finalization of the thesis report (phase "Thesis 3/3"). The student can plan and set the schedule for these phases, thus providing a way to create their own path through the thesis process and plan the schedule (see 2.1) for it, reinforcing the feel of ownership and motivating the students to follow the plan (see 2.2). This is also supported by tasks that the student can create for the phases and that they can follow by updating their status (2. Current phase), meaning that the student can set intermediate goals (see 2.3) that are visible and that their status can be monitored by both the student and the supervisor.

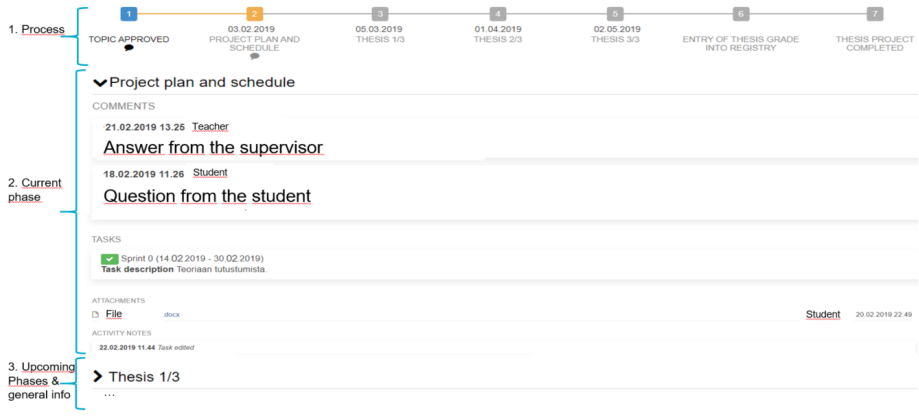

Figure 1: Supervisor's view in Wihi in a situation where a student is currently planning the thesis project and its schedule. The division of the view in three parts on the left is added for clarity.

Because the learning process in the thesis work follows the apprenticeship model, effective communication, feedback, and systematic follow-up are critical in each phase (see 2.1, 2.2 and 2.5). In Wihi, communication between the student and the supervisor is possible using messages (comments) and by attaching relevant files for the current phase (2. Current phase). This can also be used for feedback and

systematic follow-up and, in addition, it is possible for the supervisor to use activity notes. Some activity notes are generated automatically, and the supervisor can add some from neutrally worded, predefined options such as "the work is progressing as expected."

Completing a phase in a thesis is a concrete milestone in the learning process. In Wihi, when the student has completed the task planned for the phase, they communicate with the supervisor, who accepts the phase; this results in the current phase being changed in Wihi. This is a way to control and monitor the progress of both the learning process and the overall thesis process. In addition to the supervisor's control, Wihi performs automated uniform checks for all the thesis processes, such as an enforced plagiarism check before grading. Upcoming phases are visible during the entire process (Figure 1, 3. Upcoming phases & general info) as is general information, such as student information, the topic description and other relevant information related to the thesis.

Overall, Wihi provides a student-specific portal (see 2.5) where the thesis process is planned, executed, and assessed. The learning process is owned by the student (see 2.3) and supported by the supervisor. Wihi also provides visibility and objectivity to the process (see 2.4) since, for example, the communication and progress of the process is documented there.

4.2 Student and Supervisor Experiences

Students and supervisors stated that the most positive characteristics of Wihi were the visual clarity and holistic view to the learning process; everything dealing with the process was on the same view. Most interviewees also mentioned seeing specific improvements in the process, either in entire phases or in certain details of them (see 2.3); the final phase is now clearer (student), and assessment is now done within in the same system (supervisor). In addition, some mentioned characteristics like process automation; credits from the thesis being transferred to the study register system automatically, streamlined process, process guidance, and enforcement; certain steps being mandatory, easier communication; connecting the student and the supervisor; and overall ease of use.

For negative features, the highest number of answers cumulated to the opinion that the system did not have a certain desired function or that the feature did not function as the user expected. Some interviewees also felt confusion at some point, typically over a technical problem; do the credits really transfer to the study register system (supervisor); in phase 1/3, there are several opportunities to hand in the report (student). Most supervisors and one student interviewee had detected some sort of resistance to change; many students still send emails (supervisor).

Based on the answers, the process has been improved and is now more transparent (see 2.4); Wihi reduces the confusion (student); the plagiarism check is now used for 100% certainty (supervisor); the monitoring of student processes was more difficult without Wihi (supervisor).

The interaction between students and supervisors (see 2.1) has also improved, according to all interviewees; the interaction is more organized now (supervisor), but many still stated that there has been no change. Some negative aspects were also reported; If the university's email address is not used, the notices sent via Wihi at the beginning of the process are not received (student); the text editor in Wihi is not at the same level as email (supervisor).

The students were asked if the communication with the supervisor is easier using Wihi than with standard emails. Of the six students, two gave only positive aspects, two did not see any difference, and one replied that, from a process point of view, it is handy that everything is in the same place (see 2.5), but some other tools like Moodle (learning platform) have to be used. Four students estimated that the process benefitted from Wihi, one suspected that it did not make any difference, and one did not have much experience because a greater part of the process was still handled outside Wihi.

Studying the available documentation and observations showed that there were some difficulties with terminology and combining old practices related to the thesis process, and some of these only came out when Wihi was implemented or used. However, based on the Wihi log files, the re-engineered thesis process has been taken into use comprehensively.

5 Discussion and Conclusions

Although the developed tool, Wihi, was rather new to the users at the time the interviews were done, we observed remarkably small amount of change resistance. Some criticism was focused on the features of Wihi, but mainly the changes were welcomed. It was seen that Wihi enables flexible design and follow-up for all thesis parties. In addition, students setting and completing tasks, as well as phase approvals and feedback from the supervisor helps students to motivate in their projects.
It was appreciated that the tool developed for supporting personalized learning not only supports the students' flexibility but also the supervisor' ability to keep track of the situation and to supervise each student individually based on their own plans. In addition, since Wihi is not bound by time or a place, it gives supervisors more flexibility to organize their work. Visibility of the process has also improved: supervisors are able to follow the progression of students, students get comments, feedback, and guidance on time, and program managers and coordinators see what the whole situation is: how many students will graduate and whether there is a need for special arrangements (supporting courses, etc.).

The accumulated data was also considered useful. Both students and supervisors valued the comments, interim versions and other project documentation saved in one place during the project, but the data is valuable in the thesis evaluation phase as well. In addition, if complaints occur, it is easy for external reviewers to evaluate the project. We see that saving all learning process data to one student-specific portal is always important in personalized leaning, and reliable data collected in one place opens interesting possibilities to use machine learning and AI solutions to analyze the data and support and develop the personalized learning further. This is a one of the main topics of future research.

In this study, we found that the developed thesis supervising system, Wihi, helped not only students but also supervisors to get rid of the known challenges of personalized thesis projects by providing necessary process support while remaining flexible. Also, personalized thesis process requires more flexibility on the organizational level, for example, because the starting and ending points of the personalized thesis processes differ from student to student. But, organization also benefits from personalization and from Wihi, for example, by getting current data

on the progress of the individual thesis processes, as well as having visibility to the processes instead of just getting the results afterwards.

The thesis process can be considered as a good example of personalized learning, and the principles applied in digitalizing the thesis process can be applied in other teaching and learning processes. The next research step is to elaborate the applied principles in other teaching processes in order to enable continuous, personalized learning.

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Translating Business Process Models to Class Diagrams

A controlled experiment

Matthijs Berkhout[1], Sam Leewis[1] & Koen Smit[1]

[1] HU University of Applied Sciences Utrecht, Digital Ethics, the Netherlands, matthijs.berkhout@hu.nl, sam.leewis@hu.nl, koen.smit@hu.nl

Abstract Choreography of business processes can track messages between different services. At the time of writing, there are no guidelines to draw a UML Class Diagram from the Business Process Choreography. This paper reports an experiment using a set of guidelines. Objective: Evaluate the subjects' performance and perceptions when applying the BPc2Class-guidelines and BPc2Class-discovery process. Method: To measure the performance and user perception of both ways of mapping the processes, a comparative experiment was conducted with 38 subjects. The subjects, being master students, solved a process case in the first session and a guidelines case in the second session. A survey was filled in by the subjects to measure the user perception variables. Results: The results indicated that the guidelines showed significantly better results in five out of the six measured variables. Conclusion: Based on the findings and limitations of this research the use of guidelines looks promising, but future research is necessary to further generalize the conclusion.

Keywords: business process model, class diagram, translation, experiment, BPc2Class.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.22
ISBN 978-961-286-362-3

1 Introduction

Following the model-driven-design (MDD) paradigm, static structures can be derived from business process models (Bentley, Ditmann, & Whitten, 2000). These business process models are drawn to assist organisations in dealing with all services and processes nowadays (Xu, 2011) and are commonly mapped using the Business Process Modelling and Notation (BPMN) standard (OMG (Object Management Group), 2015). This standard consists of numerous approaches to model business processes. The most common approach is to orchestrate business processes into a model, but there is also another approach. The choreography of business processes tracks the messages between different services (Peltz, 2003). From these Business Process Choreography (BPC) diagrams, the static structures in general and the UML Class Diagrams (CD) in particular may be derived (González, España, Ruiz, & Pastor, 2011).

Although research has been conducted on this aspect (González et al., 2011) there are no guidelines for the transformation of BPC diagrams to Class processes, which is referred to as BPc2Class. In this paper, a set of guidelines and a guiding process will be proposed and tested. To be able to do so, the following research questions have been devised:

RQ1: *Will the subjects applying the BPc2Class-discovery process show different performance results in the output models than the subjects applying the BPc2Class-guidelines?*
RQ2: *Will the subjects applying the BPc2Class-discovery process show different perceptions than the subjects applying the BPc2Class-guidelines?*

The main objective of this research is to analyse BPc2Class-guidelines and the BPc2Class-discovery process, concerning their performance and perception in order to create a traceability link between the BPC and the CD. The rest of the paper is structured as follows: section two presents a background and introduction of the BPMN and CD modelling methods. Section three describes the experiment design. Section four contains the results and section five consists of the analysis of the executed experiment. Then, in the last section the conclusion and future research directions are elaborated upon.

2 Background & Related work

Organisations are in need to manage their business processes (van der Aalst, 2013a). These processes are composed of multiple less complex sub-processes and activities that are interrelated and hold a vast amount of knowledge on specific domains of the organization (Kock Jr & McQueen, 1996). Davenport (1993) defines business processes as: "*structured, measured sets of activities designed to produce a specified output for a particular customer or market.*" Business processes can be very complex and rely heavily on information systems (Aguilar-Savén, 2004). Due to this, it has become important to model business processes. Process models assist in managing and understanding this complexity by providing diagrammatic notation of the processes, providing ways to discuss and improve them (van der Aalst, 2013b; van der Aalst, ter Hofstede, Weijters, & Weske, 2003). One of the effective ways to model business processes is through subject-oriented business process management (Fleischmann, 2014). This approach puts actors of processes at the centre of attention to deal with business processes. This gives a new perspective on the organisational environment and therefore helps meeting the requirements from organisations.

The modelling itself is usually supplemented by a notation standard, BPMN (Chinosi & Trombetta, 2012). The industry standard for modelling business processes is BPMN 2.0, but a more subject-oriented approach is the choreography of business processes, where messages are tracked between different services (Peltz, 2003).

Business processes help to define a business strategy, however, it is key that information technology is aligned to this business strategy (Henderson & Venkatraman, 1999). Therefore, it is important to design class diagrams which ensure that the information systems support the business processes. There are multiple ways to make sure this is the case, of which one of them is deriving the class diagrams from business process models. The alignment of business processes and class diagrams can be related to traceability in information systems. Traceability can provide insight into system development and top-down and bottom-up program comprehension (Lucia, Fasano, Oliveto, & Tortora, 2007). Gotel and Finkelstein (1994) analysed the problem in the requirement traceability domain. Requirements traceability in information systems refers to the ability to trace, describe and follow the path of a requirement in both a forwards and backwards direction (Gotel & Finkelstein, 1994). Gonzalez et al. (2011a) describe a method for deriving a Class

Diagram from business process models, e.g. a BPc diagram. Testing this method during lab demos has shown the value of this model, but also that this model requires optimization and extensive testing.

Some experiments have been conducted in the past regarding the field of requirements traceability. Shin and Sutcliffe (2005) studied the effectiveness of a tool for providing traceability between scenario models and requirements. Subjects that used the tool generated better scenarios, leading to improvements in requirements elicitation and validation.

The uniformity of domain models derived from Use Cases with respect to those that derive from InfoCase models is studied by Fortuna et al. (2008). They show that the use of InfoCase models can reduce the problem of inconsistency among domain models. España et al. (2009) also performed an experiment to evaluate requirements engineering methods, the methods being communication analysis and use cases. The use of communication analysis shows greater quality in completeness and granularity. A pilot experiment by España et al. (2011) analyses whether the OO-Method benefits from integration with Communication Analysis. They concluded that the pilot was promising and has the potential to verify that integrating Communication Analysis with the OO-method has benefits. The experiments mentioned above show that using experimental research provides insight into traceability dilemma's in research.

3 Experimental design

To answer the research questions the following two-sided hypotheses are formulated for each variable measured in the experiment, each H0 hypothesis has a corresponding alternative hypothesis H1:

Hypothesis 1

Null hypothesis, H_{10}: The output models obtained from the BPc2Class-discovery process show the same degree of validity as the output models obtained from the BPc2Class-guidelines.

Hypothesis 2

Null hypothesis, H_{20}: The output models obtained from the BPc2Class-discovery process show the same degree of completeness as the output models obtained from the BPc2Class-guidelines.

Hypothesis 3

Null hypothesis, H_{30}: The output models obtained from the BPc2Class-discovery process show the same degree of efficiency as the output models obtained from the BPc2Class-guidelines.

Hypothesis 4

Null hypothesis, H_{40}: The level of usefulness is the same for the BPc2Class-discovery process as the BPc2Class-guidelines.

Hypothesis 5

Null hypothesis, H_{50}: The level of ease of use is the same for the BPc2Class-discovery process as the BPc2Class-guidelines.

Hypothesis 6

Null hypothesis, H_{60}: The level of intention to use is the same for the BPc2Class-discovery process as the BPc2Class-guidelines.

3.1 Variables

This research identifies two types of variables (Wohlin et al., 2012), the response variables and the factors and treatments. The response variables are related to the effects studied in the experiment caused by the manipulation of independent variables (Juristo & Moreno, 2001). This research decomposes the response variables in performance response variables and perception response variables which are derived from literature analysis. Performance is divided into: 1) Validity, 2) Completeness and 3) Efficiency. Perception is divided into 1) Usefulness, 2) Ease of use and 3) Intention to use.

The factors and treatments (also artefacts) are the independent variables whose effect on response variables this research wants to understand (Juristo & Moreno, 2001). The factor level consists of two factors: 1) Traceability strategy and 2) Input models. The treatments or artefacts in this research are the different strategies namely: BPc2Class guidelines and the BPc2Class discovery process, and the input models. These models consist of Business Process Choreography models and UML Class Diagrams. Table 1 shows a summary of the research questions, hypotheses, response variables and metrics.

Table 1: Summary of RQs, hypotheses, response variables and metrics

RQ	Hypotheses	Response variables	Metric
RQ1	H1	Validity	M1. Comparison of output models
RQ1	H2	Completeness	M2. Comparison of output models
RQ1	H3	Efficiency	M3. Completeness/Time
RQ2	H4	Usefulness	M4. Likert scale
RQ2	H5	Ease of use	M5. Likert scale
RQ2	H6	Intention to use	M6. Likert scale

3.2 Experimental subjects

This study is conducted among a group of master students from a university in the Netherlands. All subjects filled out a demographic questionnaire, prior to running the experiment, in order to characterise the population. The subjects rated their knowledge in Business process modelling and UML diagrams on a 5-point- Likert scale (where 1 is low and 5 is high). Subjects with a three (average) or higher on a 5-

point-Likert scale can be considered to have good knowledge of the technique. The results state that 71% of the subjects have good knowledge of Business Process Modelling and 76% have good knowledge of UML diagrams. The subjects are also asked if they have any experience regarding conceptual modelling or requirements engineering. Out of the 38 subjects, 63% said that they have experience with conceptual modelling or requirements engineering through, for example, courses, but no students have real work experience within an organisation in this field. From the subjects, 37% said they have no experience with conceptual modelling or requirements engineering.

The choice for this group of subjects has been made based on two reasons. First, Höst et al. (Host, Regnell, & Wohlin, 2000) describe that the differences between students and professionals are only minor. The second reason is the exploratory nature of this research as no previous experiments in this context have been found to the knowledge of the researcher.

3.3 Experimental objects and instruments

The experiment intends to measure the difference between two treatments, the BPc2Class discovery process and the BPc2Class guidelines. Both treatments are drafts, based on the works of Espana et al (2012) and aim to support professionals in completing the experimental task, that is, deriving a Class Diagram from a communication-oriented business process model.

The first experimental object, the discovery process, defines a 5-step process to guide the process of discovering and improving traceability links between a BPc and a Class Diagram. The second experimental object, the guidelines, provides a systematic technique for deriving a Class Diagram from a BPc. These guidelines consist of 12 steps, through which a complete Class Diagram is created. These treatments are tested on two input models per treatment; therefore, this experiment requires four test cases, two for each session as shown in Table 2. Due to space limitations, these guidelines are available upon request.

Table 2: The design used in the experiment: 2^4 factorial design

	Treatment 1		**Treatment 2**	
	Artefact A_1	**Artefact B_1**	**Artefact A_2**	**Artefact B_2**
Session 1	Subjects 1-19	Subjects 20-38	X	X
Session 2	X	X	Subjects 1-19	Subjects 20-38

Because the size and complexity of the treatments impact the test results (Basili et al., 1996), and therefore could threaten the internal validity, isomorphic models are used, i.e., the models A_1 and B_1, which are used for the guidelines, are isomorphic to respectively A_2 and B_2. For example, case A_1 uses the context of a hiring process for a company, whereas case A_2 is the enrolment procedure at an educational institute. A summary of these experimental objects can be found in Table 3.

Table 3: Summary of experimental objects

Factor	**Artefacts**	**Objects**
Traceability strategy	Guidelines	BPc2Class guidelines
	Process	BPc2Class discovery process
Input model	A_1	BPc_1
	A_2	Isomorphic BPc_1 + 40% UML CD
	B_1	BPc_2
	B_2	Isomorphic BPc_2 + 40% UML CD

Aside from the experimental objects, the subjects received guidelines for executing the experiment. These guidelines included a short description of the input models and the required output models. To measure the metrics, given in table 2, several tools are used. The first two variables, Validity and Completeness, will be based on a comparison between the input- and output models and scored on a scale of 0 to 100%. The measurement method for these variables is based on the quality model framework by Lindland et al. (1994).

The measurement of time is done by the subjects as part of the experiment and is done using a chronometer. The completeness of the model is then divided by the time to calculate the efficiency, Panach et al. (2015) show a similar method for calculating efficiency. For assessing the usefulness, ease of use and intention to use, a survey will be held among the subjects. This survey is based on the Method

Evaluation Model by Moody (2003). Table 4 shows a summary of all variables and the experimental objects and tools related to these variables.

Table:4: Summary of experimental objects and tools

Variables	Metric	Tools and instruments
Validity	Comparison of output models	The quality model framework (Lindland et al., 1994)
Completeness	Comparison of output models	The quality model framework (Lindland et al., 1994)
Efficiency	Completeness/Time	Chronometer
Usefulness	Likert scale	Survey based on Moody (2003)
Ease of use	Likert scale	Survey based on Moody (2003)
Intention to use	Likert scale	Survey based on Moody (2003)

3.4 Experimental procedure

All subjects filled in a demographic questionnaire before the experiment to determine if the target audience is reached and to identify the subject's background.

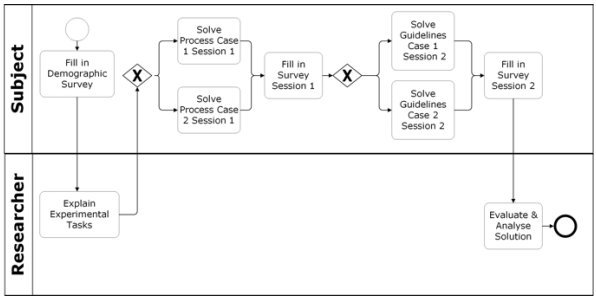

Figure 1: Summary of the experimental procedure

The experiment itself was conducted in two sessions, spread over the first two weeks of the course. Both sessions were two hours and were in the same room on the same day and time of the week with one week between assignment one and assignment two. The first session consists of an assignment where the subject creates a class diagram from a Business Process Choreography with the help of the BPc2Class-discovery process. The subject receives a partial class diagram and should complete this. The time subjects need for the assignment is measured and after the first session

the subjects will fill in a survey to check what the ease of use, the usefulness and the intention of use are for the BPc2Class-discovery process. Session two starts with another assignment. This assignment consists of creating a class diagram from a Business Process Choreography with the help of BPc2Class-guidelines. The subject receives the process and the guidelines and should create a complete class diagram. During the solving of assignment two, the time a subject need for solving the assignment is measured again. After solving the second assignment another survey with questions about the ease of use, the usefulness and the intention of use of the BPc2Class-guidelines is filled in.

When the experiment is done, all data retrieved from all subjects will be shared among the researchers and will be evaluated and analysed. Figure 1 shows a summary of the experimental procedure.

4 Results

4.1 Descriptive statistics

After the experiment, all data was gathered in one data set. Out of this data set, the completeness, validity and efficiency were calculated. The user perception was taken from the survey results. Before calculating the value for each of the three perception values, the Cronbach's alpha was measured. In all cases, the internal validity was sufficient according to Cronbach's Alpha. After that, a Shapiro-Wilk test of normality was performed on the complete dataset. The only normally distributed metric was the perceived usefulness. The values for validity and completeness were given in percentages and the descriptive statistics already show a small difference in the validity and completeness between the process and the guidelines, as the results for the guidelines were slightly higher. The measured efficiency, which was given as a factor, calculated from the completeness and time consumed, was also slightly higher for the guidelines.

The metrics regarding user perception were measured using a five-point Likert scale and were therefore given as a value between 1 and 5. Except for the perceived intention to use the process, all metrics were slightly positive, with values ranging between 2.7 and 2.9. The perceived usefulness for the guidelines was slightly higher than the other metrics, with a value of 3.15.

The results for both the guidelines and the process were also analysed per case. Aside from the descriptive statistics, a Wilcoxon-Mann-Whitney-test was used to test whether the results from case 1 significantly differ from the results of case 2. For the BPc2Class-discovery process this was not the case, nor for the Completeness and Efficiency metrics of the guidelines.

4.2 Hypothesis testing

In order to answer the research questions, the hypotheses must be tested. This subchapter elaborates on that part. Per hypothesis, a statistical test was completed to assess whether there is a significant difference between the variables. Depending on whether the variable is normally distributed, the variable is tested with a non-parametric (Wilcoxon-Mann-Whitney) or a parametric (paired t-test) statistical test. First, the hypotheses from the first research question were tested, followed by the variables from the second research question seen in figure 2.

Hypothesis	Research Question	W-value	p-value
H1 (validity)	RQ1	969	0.0008
H2 (Completeness)	RQ1	848	0.0053
H3 (Efficiency)	RQ1	876	0.0015
H5 (Ease of Use)	RQ2	663	0.8655
H6 (Intention to use)	RQ2	517.5	0.0993

Hypothesis	Research Question	T-value	p-value
H4 (Usefulness)	RQ2	1.2532	0.2147

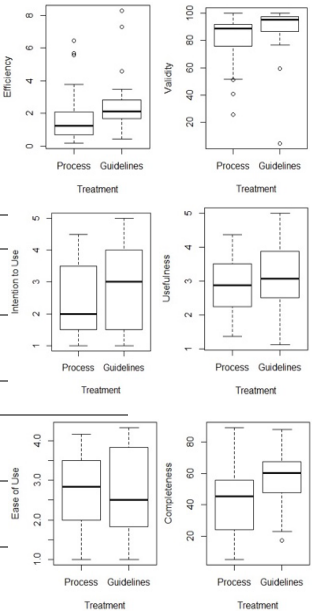

Figure 2: Results

Table 5 shows the retaining or rejection of the hypotheses for the variables:

Table 5: Hypothesis retained or rejected

Variable	Significant (p<0.05)	Retained /Rejected	Variable	Significant (p>0.05)	Retained/ Rejected
Validity	Yes	Rejected	**Ease of Use**	No	Retained
Completeness	Yes	Rejected	**Intention to use**	No	Retained
Efficiency	Yes	Rejected	**Usefulness**	No	Retained

5 Future work

Since there was no literature found on the BPc2Class-discovery process and the BPc2Class-guidelines the results cannot be related to existing evidence on this particular subject. However, this experiment does show relations to existing research on the design and method of this experiment. The work presented in the related works showed similar controlled experiments in the research field of information systems traceability.

The research showed that variables based on the quality framework by Lindland et al. (Lindland et al., 1994) and the Method Evaluation Model by Moody (Moody, 2003) can be used to assess whether conceptual models have quality and to evaluate subjects perceptions and satisfaction. This is in line with the previous experiments done in information systems traceability and helps to extend the basis which the framework and model have for experimentation in information science.

By using the framework and model, this experiment compared the BPc2Class-discovery process with the BPc2Class-guidelines in terms of validity, completeness, efficiency, usefulness, ease of use and intention to use. The first research question is as follows:

RQ1: *Will the subjects applying the BPc2Class-discovery process show different performance results in the output models than the subjects applying the BPc2Class-guidelines?*

The first research question can be answered by looking at the first three hypothesis tests. The first three hypothesis tests were based on the variable's validity, completeness, and efficiency. All three tests showed a significant difference between the process and the guidelines, seen in figure 2. The data shows that the means from the guidelines are higher than the means of the process, which might suggest that the guidelines show better performance results than the process.

The second research question is as follows:

RQ2: *Will the subjects applying the BPc2Class-discovery process show different perceptions than the subjects applying the BPc2Class-guidelines?*

This research question can be answered by looking at the last three hypothesis tests. These tests involved the variables usefulness, ease of use, and intention to use. All three tests showed no significant difference between the process and the guidelines, seen in figure 2. Based on the findings of the tests, it can be concluded that the subjects do not have different perceptions of using the process or the guidelines.

For an experimental study, the results must be valid. This study suffered some validation threats. The first limitation appeared during the second session, as the subject had already undergone treatment from the first session. This could cause a construct validity error. Maturation is also a validity error that occurred as people are familiar with the process in the second session. This is partly avoided by using isomorphic models, but some threat still existed. The next limitation is the use of partly filled in models. This could cause a bias against the models without an example. Lastly, as the subject population consisted only of students it is not easily generalizable to other populations.

The future work suggested in this section is twofold, one being more empirical activities and the other a suggestion for a design project. The first suggestion for future empirical activities with the focus on Business Process Choreography and Class diagrams can be to have another group of subjects doing the experiment but to train them in advance. Next to the training and control group, the successive

empirical activity could also involve more and more diverse subjects, especially using professional subjects. This will result in data that will be more generalizable. To make conclusions about whether guidelines are, in general, better than a process, more empirical activities with different conditions should be conducted.

The second suggestion for future work, after further validation of these results, could be conducting a design project. A possibility is translating the guidelines in automated software, the guidelines are then rules that have to be followed and implemented. When the guidelines are automated in software, empirical activities could be conducted to see whether this automated software show good results regarding traceability in information systems.

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COMPETING WITHIN AGGREGATORS: COMPETITIVE MOVES IN THE DELIVEROO ONLINE DELIVERY PLATFORM

JOAQUIN RODRIGUEZ[1] & GABRIELE PICCOLI[1,2]

[1] Louisiana State University, Business Education Complex, Baton Rouge, United States of America, e-mail: gpiccoli@cct.lsu.edu, jrod122@lsu.edu
[2] University of Pavia, Pavia, Italy, e-mail: gpiccoli@cct.lsu.edu

Abstract Aggregators are platforms that also control a marketplace for the suppliers' innovations. Suppliers competing within aggregators are limited by the technology and governance rules of the platform owner. As a consequence, aggregators influence the type and complexity of competitive moves suppliers can implement. Our research investigates the drivers of suppliers' competitive advantage. We incorporate existing literature on competitive action to identify the categories of moves available to suppliers. Furthermore, we identify three types of orthogonal moves that are unique to competition within aggregators. Finally, we illustrate our advanced categorization in the context of a major food delivery platform. Our preliminary results confirm that suppliers, while bounded to resources exposed by the aggregator, have the opportunity to implement an heterogenous portfolio of moves in their pursuit of competitive advantage. This result calls for empirical research in the context of competition within aggregators in general, and food delivery platforms specifically.

Keywords: platform, marketplace, aggregators, competitive moves, online delivery platform.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.23
ISBN 978-961-286-362-3

1 Introduction

Over the last 30 years technology platforms have emerged as critical elements of all technological layers (e.g., operating systems, browsers) and in several application domains (e.g., payments, game development). Aggregators, a type of platform, are increasingly drawing research, media and regulatory attention. Aggregators (1) mediate the relationship between customers and suppliers[1] by managing a marketplace; (2) serve customers at virtually zero marginal costs; (3) exhibit positive cross-side network effects. Examples include Google Search, Amazon Marketplace, Apple iOS, TripAdvisor, Expedia, and Deliveroo. Aggregators rise to prominence by creating superior value for customers. Consider Google Search and the aggregation of demand for online information seeking. As the number of Web pages increased exponentially, the precision of the Google's page-rank algorithm enabled the firm to provide better answers to customer search queries. Google became the de-facto organizer of information on the Web, a valuable service for customers. Whether it is the search for information, the procurement of travel, or the ordering of food, aggregators come to own customer relationships by providing a superior solution to a customer "job to be done" (Ulwick 2002).

The competitive performance of aggregators have received significant attention (see for a review: Mcintyre and Srinivasan 2017; de Reuver et al. 2018). However, we have yet to fully understand how suppliers can successfully compete within aggregators, given the idiosyncrasies they present. First, aggregators create synthetic algorithmic marketplaces that are not bounded by the limitations of the physical world. Being algorithmic, the competitive rules within aggregators can evolve arbitrarily and unpredictably. Second, aggregators mediate the interaction between suppliers and their customers. Unlike the traditional supply-retail relationship, aggregators (e.g., Expedia) intermediate the relationship between suppliers (e.g., hotels) and their customers (e.g., travelers). Because of this characteristic, they are a special case of platforms (see below), in which suppliers are limited by the competitive moves afforded by the aggregators. Third, the algorithmic mediation and the matching mechanisms implemented by aggregators exert pressure toward the commoditization of suppliers. Having to comply with the aggregators' technological prerequisites and governance rules, while being unable to own the

[1] Suppliers as those organizations that leverage the platform resources to produce digital innovations (i.e., new market offerings, business processes, or models).

transactional relationship with their customers creates obstacles to competitive differentiation by suppliers.

We offer three contributions to the literature. First, we advance a conceptualization of aggregators as a special type of platforms. Second, we identify the classes of competitive actions that suppliers can deploy when competing within aggregators, introducing the notion of platform moves, marketplace moves and outside moves. Finally, we illustrate the above categorization in the context of digital food delivery aggregators. The work is important because the vast majority of constituencies for our research are suppliers and, as aggregators gain prominence, these firms must find ways to compete within their synthetic algorithmic marketplaces.

2 Definitions

2.1 Platforms

We adopt an information systems perspective, defining platforms as a socio-technical systems with a layered architecture that facilitates digital innovation by suppliers through the exposure of digital resources (Parker et al. 2017; Rodriguez and Piccoli 2020). Digital innovation is "the creation of market offerings, business processes, or models that result from the use of digital technology." (Nambisan et al. 2017, p. 224) Platforms are structurally different from traditional applications because they provide generic resources that heterogeneous supplier communities can leverage and combine to produce their digital innovations (Gawer 2014; Hanseth and Lyytinen 2010). The degree to which a platform enables digital innovation is a function of its "generativity" (Zittrain 2005). We observe different levels of generativity as platforms can diverge in the breath of possible uses, and in the degree to which they facilitate the achievement of desirable objectives. Consider the example of the Windows .NET software development platform. .NET facilitates the development of a broad range of software applications. However, due to its general design, .NET requires significant efforts to develop complex applications in specific domains (e.g., games). On the other hand, the Unity game development platform facilitates the achievement of highly complex, yet narrow, objectives that would be hard to realize by independent game developers using general software development platforms.

2.2 Marketplaces

Economist commonly refer to the entity that facilitates the transaction in two-sided or multi-sided markets as the platform sponsor or owner (Eisenmann et al. 2009). Much previous research uses the terms market, marketplace, and platform interchangeably. The concepts are related, but distinct. A market is a specified category of potential buyers, like readers in the market for books. A marketplace (e.g., the Amazon Marketplace) is the space, increasingly digital, where people meet for the purpose of trade. It facilitates the exchange of products, services, and information between buyers and sellers (Pavlou and Gefen 2004).

The recent success of the AppStore and Google Play demonstrates how ownership of a marketplace can be a source of competitive advantage for platform owners. However, it is not a defining prerequisite for a platform to own a marketplace. Windows, the first dominant software platform, did not integrate a marketplace and suppliers were free to distribute their innovation (software applications) independently – some chose OEM partnerships, some retailers, some used mail order or, after the commercialization of the Internet, direct downloads. Marketplaces differ in the degree of control exerted by the owner. In some cases, like Apple, the DRM module in the iOS kernel guarantees full control over the distribution channel of apps through the AppStore (unless the device is jailbroken). In others, like Android, the same platform may host multiple competing marketplaces for the suppliers' digital innovations (Karhu et al. 2018).

Marketplace owners determine the technological prerequisites and governance rules for participation (Ghazawneh and Henfridsson 2015). Where marketplace participants can adopt opportunistic behaviors, the owner also functions as an enabler of trust by protecting customers (e.g., by granting favorable refund policies) or reducing information asymmetry (e.g., by implementing rating systems) (Pavlou and Gefen 2004). Finally, through the implementation of discovery features, such as search functionalities, filtering functionalities, and recommendation systems, marketplace owners impact the value capture potential of all parties (Li et al. 2018).

2.3 Aggregators

An aggregator is a type of platform that integrates a marketplace. It facilitates digital innovations (like platforms) and transactions between suppliers and customers (like marketplaces). Aggregators have three defining characteristics: First, they mediate the relationship between customers (e.g., consumers) and sellers (i.e., suppliers) via synthetic algorithmic marketplaces. Suppliers are incentivized or required to distribute their innovation in the aggregator's own marketplace.

Second, aggregators can serve customers at virtually zero marginal costs. Aggregators standardize interactions between customers and suppliers, thereby reducing the complexity, and cost, of managing transactions. For example, the ordering and fulfillment process in a food delivery aggregator is standardized for all participating restaurants. Membership in the aggregator's platform and marketplace implies respect of technological prerequisites and governance rules by suppliers, rules that are typically algorithmically enforced. This process of adjustment is inherently commoditizing, as it leads to an increase in the comparability of suppliers, and a reduction in the options they have for differentiating their offer.

Third, aggregators exhibit positive cross-side network effects (Katz and Shapiro 1994) because their value creation potential depends on aggregating demand on the customer side and aggregating a range of suppliers on the supply side. Such network effects often engender winner-take-all dynamics leading successful aggregators to command monopolistic positions that force suppliers to join.

3 Competing in Aggregators

The premise of this study is that the emergence of aggregators significantly influences the competitive actions available to suppliers. Unlike traditional marketplaces, organizations that participate in aggregators are impacted by digital technology in two ways. First, they are limited in the extent to which they can innovate by the degree of generativity of the platform they chose. Second, they are bound by the algorithmically enforced marketplace governance rules. It is within these limitations that suppliers craft their competitive actions.

3.1 Competitive Actions

Organizations compete by a series of actions designed to recombine resources in the pursuit of improved performance (Henfridsson et al. 2018). A competitive action is "any externally oriented, specific, observable competitive move initiated by a firm to enhance its relative competitive position" (Smith et al. 2001, p. 12). In the IS tradition, competitive actions are enacted through initiatives that depend on the use of digital technologies at their core (Piccoli and Ives 2005). Previous studies have grouped competitive actions into pricing, marketing/promotional, product, product presentation, payment, capacity/scale, service, and operations moves (Ferrier et al. 1999; Li et al. 2019; Yu and Cannella Jr 2007). These studies assume that the competitive environment complexity and dynamics are general features of the industry. However, when firms compete within aggregators, they are subject to the idiosyncratic dynamics explicitly determined by the aggregator (Kapoor and Agarwal 2017). Therefore, suppliers that participate in an aggregator can be subject to different competitive dynamics with respect to that of the industry. To account for this specificity, we add an orthogonal set of three classes of competitive action types that are unique to competition within aggregators: platform actions, marketplace actions and outside actions.

- Platform actions are moves the suppliers enact to create their digital innovation by leveraging the generic digital resources exposed by the platform (Henfridsson et al. 2018). More generative platforms afford higher optionality, and thus provide the suppliers with a wider array of competitive actions. When exploiting platform actions, suppliers seek to create synergy between their innovation and the platform in order to improve their competitive advantage versus other suppliers (Cennamo et al. 2018; Tiwana 2018).
- Marketplace actions are moves the suppliers enact to improve their visibility by influencing the filtering, search, and/or the algorithmic dynamics created by the aggregator. As aggregators scale, and competition between suppliers increases, it becomes of critical importance for suppliers to achieve superior visibility in the marketplace. As customers face high search costs when browsing through a larger number of supplier offerings, superior visibility offers a competitive advantage by improving the probability that customers will find and transact with a supplier (Carare 2012; Li et al. 2018). Furthermore, visibility is particularly important in aggregators, as most exhibit a Pareto distribution, where a small number of suppliers capture the majority of transactions (Garg and Telang 2013).

- Outside actions are competitive moves the suppliers enact independently of the aggregator's platform resources. They do not leverage any platform or marketplace functionalities. Outside actions can lead to significant competitive advantage, as they offer suppliers the opportunity to implement moves with high degree of differentiation potential. Outside actions therefore tend to depend on the general ecosystem and industry conditions, instead of the characteristics of the aggregator. However, outside actions are not insulated from the aggregator's influence, exerted through contractual or algorithmically enforced governance and technical rules. For example, until 2015, Booking.com prevented hoteliers to offer lower prices in competing distribution channels, including the hotel's own website. To limit fraud, Amazon's algorithms trigger account reviews when a seller experience sudden increases in the number and dollar amount of their monthly transactions. As a side effect, such triggers limit the use and effectiveness of aggressive marketing campaign outside of the Amazon marketplace.

Digital food delivery platforms are emerging examples of aggregators, where competition between and within aggregators is evolving rapidly. In the remainder of this paper we use the case of the dominant European player to demonstrate and categorize competitive actions by suppliers (i.e., restaurants).

4 The Case of Deliveroo

Founded in London in 2013, Deliveroo facilitates the implementation of food delivery by restaurants that would otherwise lack such service. The firm rapid growth has positioned it as one of the major food delivery aggregators in Europe. With more than 5,000 employees it generated over $300 millions in revenue in 2019. The Deliveroo platform exposes a number of digital resources enabling restaurants' delivery services. Examples include menu configuration tools, order and payment acceptance, and a large network of riders. These resources are accessible to suppliers via a dashboard or through a set of APIs that can integrate with restaurants existing Point of Sale systems (POS). Deliveroo is an aggregator, because its platform integrates a marketplace where diners (customers) can browse through all the restaurant offerings (suppliers). In the UK the number of restaurants delivering to any given location varies between ten and 800. Thus, where the number of restaurants is significant, discovery becomes critical to guarantee relevance. Deliveroo offers filters and search functionalities to navigate through available offerings. Moreover, it implements an algorithmic recommendation system that

ranks restaurants in real-time depending on the probability that customers will place an order to each restaurant.

4.1 Methods

We selected the case based on two criteria. First, the emergence of food delivery platforms has intensified competition and disrupted long established competitive dynamics in the restaurant industry. Second, Deliveroo is at the forefront of technological innovation in the establishment of advanced platform resources (e.g., restaurant partner API), and sophisticated algorithmic marketplace dynamics governance rules (e.g., predictive restaurant ranking). We followed an iterative approach for categorizing the competitive actions restaurants can enact in Deliveroo. The list is compiled based on unstructured interviews with restaurateurs, the authors' analysis of Deliveroo's technology, and from public sources, such as media reports and Deliveroo's documentation. Each competitive action identified was individually coded by the two authors into one action category and type. Action categories are identified from previous competitive dynamic literature, while actions types are our proposed orthogonal classification. In case of disagreements, the coders discussed the coding until 100 percent agreement was achieved.

4.2 Case Findings

We identified 24 competitive actions (see Table 1) that restaurants can implement for improving their performance within the aggregator. Our exploratory case analysis provides interesting findings. First, our categorization shows how the majority of platform-based actions available to suppliers in food delivery aggregators (15/24) are designed to facilitate the commercialization of the restaurant's already existing offerings, through product presentation, service, and marketing moves. The aggregator affords only two actions in the product category, that simply include the introduction or removal of a new menu items or their modifiers. Therefore, given the available menu items, restaurants can differentiate their offerings by curating the presentation of the items or by improving their service levels (e.g., low delivery times).

Second, the vast majority of actions we identified are platform-based (16/24). Despite the strategic importance of visibility and discoverability in the Deliveroo marketplace, restaurants only have limited functionalities available to directly impact them. Instead, the visibility is indirectly determined by a combination of platform-based (e.g., percentage of menu items with images) and outside actions (e.g., delivery times), and is determined algorithmically by Deliveroo. Therefore, superior visibility can only be achieved by those restaurants that recognize the importance and pursue the implementation of those indirect factors that influence their visibility.

Finally, we find that Deliveroo does not facilitate the implementation of competitive moves in all categories. Although this is not unexpected, we find that restaurants can circumvent this limitation by implementing outside moves in the capability and scale/operations categories. However, for the payment's category, Deliveroo inhibits the implementation of any competitive actions by fully controlling the payment process. Furthermore, the absence of any platform-based action in the capacity and scale categories indicates a well-defined separation between the restaurants' internal operations and the aggregator.

5 Discussion

Our analysis of Deliveroo shows that to compete within aggregators, suppliers deploy a range of competitive moves aimed at performance improvements. As a consequence, different competitive move configurations can account for heterogeneous organizational performances. In particular, our orthogonal classification of competitive actions offers a new viewpoint for analyzing the strategic potential and effects of competitive actions in the context of aggregators. As competitive moves exhibit varying levels of complexity, suppliers can implement barriers aimed at preempting imitation.

Our analysis suggests that the products or service characteristics might influence the type of competitive actions available to suppliers competing within aggregators. For example, when the product is digital rather than physical, it is easier for aggregators to facilitate the development of new products at scale. Instead, when the product is physical (e.g., a household appliance), the aggregator might focus on facilitating product presentation or service action categories. However, through the process of "infrastructuring" (Constantinides et al. 2018), aggregators can extend their reach

and scope into the physical domain. Deliveroo recently started experimenting with "cloud kitchens," by allowing restaurants to increase their capacity and scale by renting delivery-only optimized kitchens to them.

The increasing control of the marketplace visibility by recommender systems demands the development of new dynamic capabilities by suppliers. Achieving a visibility advantage requires continuous sensing and adaptation by suppliers, as the aggregators' algorithms are often proprietary and constantly evolving. For example, Deliveroo recently started promoting those restaurants that use recyclable packaging materials. Quickly adjusting to this requirement with the appropriate outside moves, improves a supplier's visibility. Furthermore, when direct (e.g., ads) and indirect actions (e.g., time of delivery) for impacting visibility are available, suppliers need to optimize their combination to achieve maximum visibility.

Table 1: Competitive actions available in Deliveroo

Category	**Competitive Action**	**Type**
Product: Launch new products or modify existing ones.	Add or remove a new menu item.	Platform
	Add or remove modifiers for an item (e.g., remove/add ingredient).	Platform
	Change food packaging to improve quality.	Outside
Price: Implement price cuts and sales incentives.	Change the price of a menu item/modifier.	Platform
	Launch discount, meal deals, or bundles.	Marketplace
Product presentation: Improve the product information provided to customers.	Add/change a menu item description.	Platform
	Add/change a menu item image.	Platform
	Change the items order in the menu.	Platform
	Add/modify the menu categories (e.g., starters, mains).	Platform
Service: Change the company's range or level of services provided to customers.	Change the opening hours on the delivery platform.	Platform
	Receive reservations (pre-orders) outside the restaurants' opening times.	Platform
	Set the delivery times (only for restaurant that manage their own fleet).	Platform
	Activate "busy mode" to increase the normal delivery times.	Platform
	Turn-off the delivery service.	Platform
	Mark menu items as unavailable.	Platform
	Decrease/increase delivery times.	Outside
Service/Operations	Manage own delivery riders' fleet.	Platform
Marketing: Perform advertising and promotions activities.	Add/change food category items used as filters to discover the restaurant.	Marketplace
	Create a brand page on the delivery platform.	Platform
	Launch a virtual brand, that exists only on the delivery platform.	Platform
	Launch promotions increasing traffic to the delivery platform.	Outside
Capacity and Scale: Change the company's capacity or output.	Open a "dark kitchen," optimized for delivery, and that has no access to the public.	Outside
Capacity and Scale/Operations: Change in organizational activity systems	Increase the kitchen capacity, and/or assign dedicated staff members to fulfill delivery order.	Outside
	Dedicate front-end staff to manage relationship with delivery riders.	Outside
Payment: Provide customers with multiple payment options	None.	

6 Limitations and future research

Supplier's appropriation of value within aggregators presents many idiosyncrasies that warrant future research attention to fill gaps in our understanding of competition in increasingly digital markets. We contribute to the body of knowledge on platforms and marketplaces by identifying three different types of competitive actions that suppliers can implement when competing within aggregators. However, our initial findings require the analysis of multiple aggregators within and across different industries before the external validity of our categorization is established. Future research should use our initial categorization to empirically investigate those competitive configurations that lead to superior performance of suppliers competing within aggregators. The identification of the three different types of competitive actions (i.e., platform, marketplace, outside) demands empirical investigations to determine possible differences in their relative effectiveness for short and long-term competitive position. Finally, the investigation of visibility as a source of competitive advantage has yet to receive significant attention and focused empirical attention in this area is needed.

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Exploring Governance in a Decentralized Energy Trading Eco-System

Fadime Kaya[1,2], Jaap Gordijn[1,3], Roel Wieringa[3] & Marc Makkes[1]

[1] Vrije Universiteit, Amsterdam, The Netherlands, e-mail: f.kaya@vu.nl, j.gordijn@vu.nl, m.x.makkes@vu.nl
[2] Tymlez, Amsterdam, The Netherlands, e-mail: f.kaya@vu.nl,
[3] The Value Engineers, Amsterdam, The Netherlands, e-mail: j.gordijn@vu.nl, roel@thevalueengineers.nl

Abstract Increasingly, large tech firms dominate eco-systems. From a societal perspective this is not always beneficial since these companies behave as value extractors; they charge an unreasonable high fee for their services and they can do so because they are monopolists. A possible solution to this substantial power concentration can be decentralized eco-systems, e.g., enabled by blockchain technology, in which decision power is distributed fairly. However, this comes also with the requirement that such eco-systems need a decentralized governance model. This paper explores if such a governance model can be represented by conceptual models, in particular, e3value. We answer this question by designing a decentralized eco-system in the field of electricity supply, which enables peer to peer energy trading, and checking if important governance decisions, motivated by a systematic literature review, can be represented.

Keywords: governance, decentralization, energy trading, business models, eco-system.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.24
ISBN 978-961-286-362-3

1 Introduction

Nearly every company and individual is part of at least one *eco-system*. Based on (Moore, 1996), we define an ecosystem as a collection of parties who work cooperatively and competitively to satisfy customer needs. Well known examples of eco-systems are Uber, Google, and Facebook. All these eco-systems are dominated by only one player.

Such eco-systems with a dominant player tend to do value extraction: Companies charge unreasonably high fees for providing services or goods, which is neither in the interest of, nor sustainable for society. To mitigate unfair value extraction, we propose the concept of *decentralized* eco-systems, which we define as a collection of parties who work cooperatively and competitively to satisfy customer needs, and in which decision power is fairly distributed over a (sub)set of parties in the eco-system.

Such decentralized eco-systems, specifically in the field of intensive information services, can be realized with Distributed Ledger (DLT) and Blockchain (BCT) Technology. The most well-known case of BCT is the Bitcoin, in which banks are disrupted by allowing customers and sellers to directly transact with each other, without a bank. In general, BCT enables decentralized business transactions between parties, without a powerful centralized party. However, governance of many BCT systems are poorly developed and is often an ad-hoc driven process. Bitcoin has some signs of a governance process, but the nodes play only a role at the very end of this process, namely by accepting or rejecting the revised Bitcoin protocol.

To enable a decentralized eco-system, the key question is: How to govern and design a decentralized eco-system? In a traditional eco-system, the focal company is governed hierarchically by its board of directors and control, shareholders, and ultimately the government. In decentralized eco-systems, governance evolves to a negotiation game between participants, rather than a hierarchical top-down decision process.

Based on our consultancy experience with decentralized business development projects we have seen that these projects usually do not have a sound governance system in place; in practice, the decentralized project is often driven and governed by one single enterprise, which is often also the technology provider. For

decentralized eco-systems, this is not in line with the philosophy that decision power should be equally and fairly distributed over parties in the eco-system. Even the strongest supporters of adopting a decentralized eco-system have conceded that the biggest challenge is the design of distributed governance (Zachariadis, 2019) and consider decentralized governance is an emerging research field (Alves, 2017).

The specific research question in this paper is to what extent governance decisions can be represented by conceptual models, in particular, *e³value*. The goal of conceptual models is to precisely and unambiguously represent an artefact in reality with the aim for (automated) analysis. This is precisely our long-term research objective: We want to software-support the design and analysis of governance constructs, and we refer to this field as *computational governance*.

This paper is organized as follows. In Sec. 2 we briefly explain what we mean by BCT-enabled decentralized eco-systems, and we elaborate on the notion of 'governance'. Then we explain in Sec. 3 our research methodology, which is Exploratory Technical Action Research (ETAR). A crucial element in ETAR in the involvement in a real-life project, which in our case, is a project about decentralized enabled renewable energy trading (Sec. 4). Finally, Sec. 5 presents our conclusions.

2 Governance of decentralized eco-systems

To understand governance and its layers, we revise the generic *control* paradigm of Blumenthal (see e.g., (Bemelmans, 1994) and (Leeuw, de, 1973)) to arrive at a more specific *governance paradigm* (see Fig. 1). We distinguish three governance systems: (1) the *governed* system (operations of a company) that has to obey to rules set by the governing system (e.g. the management of that same company), (2) the *governing* system that monitors and steers the governed system, and (3) the *meta* governing system that controls the governing system (e.g. the government of a country).

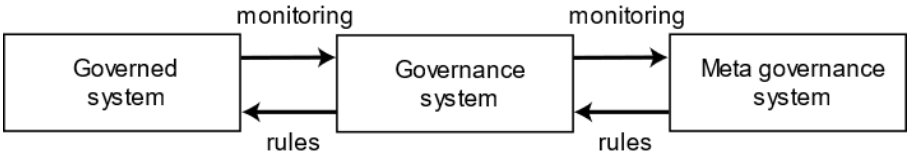

Figure 1: The governance paradigm

The rules are *normative*, e.g., the governed system should comply with these rules. (Re)design of rules is based on the monitoring of the governed system. The governed system performs *value-adding operations*, such as providing a video stream to customers in return for money (in the case of e.g. Netflix). The meta-governance system prescribes the rules for making rules (by the governance system). This implies that the governance system is a governed system at the same time. It is important that we understand *the system* as in system's theory: A system consists of entities with relationships. In our work (see also the next section), the governed system is a *decentralized network* of enterprises (e.g., a networked value constellation (Normann & Ramírez, 1993) or an eco-system (Moore, 1996)).

3 Exploratory Technical Action Research

We are interested in how to design governance for decentralized eco-systems and to what extent the governance of such eco-systems can be expressed in an *e³value* model. Often, 'decentralized governance' is considered *ex-post*, that is when governance is already in place and up for evaluation. In contrast, we study the topic *ex-ante*, e.g., as a topic of design, cf. (Erbguth & Morin, 2018). Concretely, we do so by means of a project about renewable energy that facilitates peer-to-peer energy trading. We have been actively involved in this project. We use Exploratory Technical Action Research (ETAR), following the TAR approach, which is often used in the field of Design Sciences (Wieringa, 2014). ETAR comprises the following activities: (1) problem analysis, (2) treatment design, (3) treatment, and (4) treatment analysis. The notion of 'exploratory' emphasizes that we use TAR to first *understand* decentralized governance better, which might be followed by one or more TAR engagements with the field with the goal of theory formation and evaluation of the validity of the theory.

4 Governance for peer-to-peer energy trading

4.1 Project background

We have been working on energy transition towards renewable energy project that facilitates peer-to-peer energy trading. In The Netherlands, private citizens who have photo-voltaic (PV) cells, currently may subtract the generated electricity from the consumed electricity and only pay for the net amount of consumed electricity. Effectively, the owner receives the electricity price for sold electricity that should be paid normally, if he buys electricity (in The Netherlands about 0,20 Euro/KWh). During day-time, when the sun shines, the owner may generate more electricity than he needs and sells the surplus to the net. At night, the opposite happens. Consequently, the electricity grid functions as a kind of *store*: if the PV cell owner has a surplus, it can be delivered to the grid, and if he has a shortage, he can obtain electricity from the net, and the owner pays only for the net energy bought measured over one year.

This storage is offered free of charge, while for the large scale electricity suppliers and power generators who provice this service, it is not free at all. Due to physical constraints, the amount of electricity generated in a grid should at all times equal the amount of electricity consumed. The large electricity suppliers and generators are responsible for keeping this balance, and they do so by switching on and off generators and loads if demand and supply requires that. Obviously, this flexibility does not come for free, and therefore large electricity providers complain about the attractive arrangements for private owners of PV cells.

As a result, the Dutch government has decided to depreciate the current arrangement gradually. In the new situation, owners of PV cells *directly* receive a fee if they deliver to the grid. This fee is expected to be substantially lower than the 0.20 Euro/KWh mentioned earlier (e.g. 0.06 Euro/KWh). The same happens if electricity needs to be bought. It is not allowed anymore to settle generated and consumed electricity over the period of one year.

To mitigate the decrease in revenue for private owners of PV cells, we have designed an innovative, peer-to-peer business model for energy trading. If a private owner has a surplus of energy, he first sells it to another private owner. In case of shortage, owners buy electricity first from their peers. In case all participating owners have sufficient electricity, the surplus can be sold to the electricity market, as proposed by the government. In case of a shortage, owners buy electricity from the electricity market.

4.2 Problem analysis

The problem at hand is how to design governance in a decentralized eco-system. In Design Science, the notion of artefacts is key. We express artefacts in terms of conceptual models (Brodie, Mylopoulos, & Schmidt, 2012). These models allow for a better and shared understanding of the domain at hand and facilitates automated proof of correctness of models and computer-assisted analysis of the domain at hand (e.g., compliance with governance rules set by law). We want to understand whether model-based artefacts can assist in designing and understanding governance in decentralized eco-systems.

4.3 Treatment design: Governance artefacts

One of the first questions in terms of Design Science (Hevner et al., 2004) is what the actual design artefacts are. Without having the intention to be complete, based on our previous experience with eco-system design projects, and inspired on (Wieringa, Engelsman, Gordijn, & Ionita, 2019), we propose at least the following artefacts:

- **The strategy artefact:** Identifies the participants (as governing parties), rule, regulation, and lawmakers (as governing parties), their capabilities, and the services and products offered and requested. It provides a high-level blueprint of the eco-system at hand. Such models can be expressed by e.g., the UML Business Motivation Model (BMM) (BMM 2015) or i* to represent the strategic intent of stakeholders (Yu, 1997).
- **The business model artefact:** Puts into operation the strategy of the eco-system, in terms of flows of valuable objects. It also addresses economic reciprocity. Such models can be represented by e.g., *e³value* (Gordijn &

Akkermans, 2018), the Resource Event Agent (REA) ontology (Geerts, Mccarthy, Andersen, Dunn, & Smith David, 1999), and the Value Delivery Modeling Language (VDML) (VDML 2018).

- **The business process & data artefacts:** These artefacts represent the processes, time-ordering of activities, the performance of these by resources, and interaction between activities, in terms of message flows. Also expressed is a domain model of the relevant entities, relationships, and properties. There are many possibilities to represent these artefacts, we refer here to the Business Process and Model Notation (BPMN) (BPMN 2013) and the Unified Modelling Language (UML), more specifically class diagrams (Seidl, Scholz, Huemer, & Kappel, 2015).
- **The IT artefact:** This artefact encloses a number of sub-artefacts, e.g., the relevant views of the UML (Seidl et al., 2015), such as class-, activity, state transition- and deployment models. The focus is on embodying the previous artefacts into IT components.

These artefacts become governance artefacts as soon as they are prescriptive, meaning that they set the rules for the partipants. All these artefacts can play that role.

Designing all artefacts is a significant amount of work that exceeds the reporting space in this paper. Therefore, we concentrate on the business model artefact. The strategy artefact was already known when we entered the project, namely cost reduction for PV cell owners as soon as the new energy regulation starts. The other artefacts follow once there is agreement about the business model.

4.4 Treatment: A peer-to-peer energy business model expressing governance decisions

The project consortium consists of an energy certification body, a research institute, and a BCT platform provider. To express the business model, we require a language and we have chosen for the *e³value* methodology (Gordijn & Akkermans, 2018). This a tractable and teachable method for business development specifically designed for eco-systems. Note that the traditional energy infrastructure is hierarchically and centrally orchestrated, therefore it does not provide decentralized governance for the case at hand. Consequenty, a new governance model is needed.

In figure 2, we model the business model for the peer-to-peer energy trading ecosystem, expressed as an *e³value* model. The model is the outcome of several workshops with stakeholders but is simplified (some parties are left out) to allow for a compact presentation in this paper. Prosumers are *market segments* because there are many of them (e.g. households). Prosumers own PV cells and likely batteries (e.g., in their electric cars) to store electricity temporally. A market segment is a set of homegenous *actors*. Actors are also economically independent parties, such as the Cooperation and the Electricity Trader. The Cooperation aggregates electricity power from Prosumers and can, therefore, negotiate a better deal with the Trader. In the same way, the Trader delivers electricity against favourable conditions to Prosumers via the Cooperation if there is not enough electricity generated by the Prosumers themselves. As can be seen from the model, the Prosumer uses first energy ('consume' value activity) from its own PC cells and/or batteries.

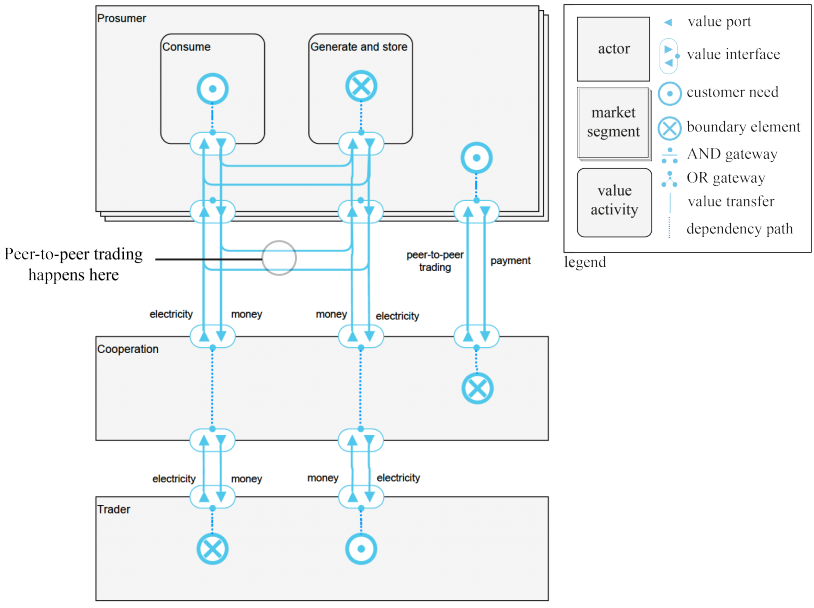

Figure 2: Peer-to-Peer Energy trading

Similarly, if the Trader generates more electricity than it requires, it first stores the energy in a battery component. If there is still a surplus of electricity, the Prosumer sells electricity to other Prosumers: the peers. The same happens if a Prosumer consumes more than it can obtain from its PC cells or batteries; then, it first obtains electricity from other Prosumers. To be attractive to all parties, the peer-to-peer electricity price should be higher than the price the Trader would pay while buying (so more than 0.06 Euro/KWh) but lower than the price the Trader charge while selling (so lower than 0.20 Euro/KWh). This gives sufficient price negotiations between Prosumers (peers). This represents the *peer-to-peer* trading. Furthermore, the Cooperation provides a service to the Prosumers, namely an IT-enabled energy trading platform. Part of the service is (dis)aggregation of electricity to the trader, to sell a surplus of electricity of the Prosumers, or to buy electricity for the Prosumers in case the Prosumer do no have sufficient electricity himself. This way, the Cooperation ensures that at all time the supply and demand of electricity are in balance, which is a requirement for the electricity grid.

4.5 Treatment analysis: Governance decisions in the peer-to-peer business model

In terms of treatment analysis, the question is whether a business model represents governance decisions adequately. In (Alves, 2017), a number of governance mechanisms have been identified based on a systematic literature review of 63 studies on governance for eco-systems. The study of (Alves, 2017) focuses on eco-systems with one dominant actor, which differs from a decentralized eco-system. However, we consider the study as an useful starting point because most of these mechanisms are also applicable to decentralized eco-systems.

In (Alves, 2017), three classes of governance mechanisms are identified that can be used to design governance in eco-systems: (1) value creation, (2) coordination of players, and (3) organizational openness & control. Each class of governance mechanism has subclasses (see below). We use these governance mechanisms to evaluate per governance mechanisms to what extent our *e³value* model for peer-to-peer energy trading (see Fig. 2) represents the governance decisions.

Value creation evalution based on our *e³value* model.

The value creation aspect considers how value is created and distributed.

- Revenue model. The revenue model shows how each actor earns money. In the *e³value* model, this is shown by means of value transfers. In the peer-to-peer energy trading case, a Prosumer pays a lower price for electricity than the fee a Trader would charge.
- Attract and maintain partners. The electricity case has a close resemblance to the idea of partnering. Effectively, partners (the Prosumers) team up to provide each other electricity and act as one to the electricity market if there is a surplus of shortage in electricity. This partnership can not easily be observed in the *e³value* model, because in *e³value*, a partnership has a different meaning, namely two or more actors offering or requesting objects of value together as one proposition.
- Stimulate co-investments and share costs. Each Prosumer has to invest in technology to participate in the eco-system. Although not visible in the graphical model, this can be represented to quantify the model, which is a standard feature of the *e³value* method. For shared-costs, all Prosumers contribute to the financial sustainability of the Cooperation. This can be seen from the value transfer "peer-to-peer trading".

Coordination of players evalution based on our *e³value* model.

Parties in an eco-system should work together in a harmonized way.

- Roles and responsibilities. A governance decision is to have a cooperation and not only Prosumers. A truly peer-to-peer system would not have a cooperation. However, the Cooperation represents all Prosumers, and these should have a say in the decision making processes of the cooperation. The *e³value* model does not represent this, e.g., does not model that a party is represented by some other party for decision making. This could be an extension of the *e³value* language (see e.g., (Sarkar & Gordijn, 2018) for a proposal on how to do this). Furthermore, value activities can represent the roles of actors. The model presents only value activities to distinguish between the consumption of electricity and the generation and storage of electricity. This is needed to represent that buyers first 'buy' electricity from themselves before buying electricity from their peers or

Cooperation. Value activities could be added to the other actors to emphasize the roles they take.

- Effective communication channels. The peer-to-peer electricity trading eco-system is supported by information technology, more specifically BCT, to avoid the emergence of a central party. Communication is not represented by an *e³value* model; other artefacts must be developed to represent this.
- Conflict management. In any eco-system, conflicts can arise, and in peer-to-peer eco-system there is no centralized party that can resolve conflicts. Conflict management is a topic by itself, it can be seen as a commercial service (then it would be visible in the *e³value* model), but also as an inter-organizational business process, and hence be modelled by a business process artefact.
- Manage resources, risk, and expectations. Resources (e.g., a capacity to perform activities) can be seen by the value activities as assigned to actors. Risks and expectations can be analyzed by the *e³value* model by quantifying it and then performing what-if analyses.

Organizational openness and control evalution based on our *e³value* model.

Eco-systems can be open (or closed) to their environment, e.g., of actors that may participate. Control refers to the actor(s) who orchestrate the eco-system.

- Autonomy. In this case, autonomy would refer to the decision power of actors in their own right. In the case of normal electricity consumption, the consumer buys electricity from a large supplier and has no decision power . For the peer-to-peer electricity case, decision power is with the cooperation. These processes can not be seen by the *e³value* model.
- Distribution of power. The peer-to-peer electricity case distributes power equally over the Prosumers. This can be seen from the *e³value* model. Prosumers are depicted as the same kind of actor, and consequently, their need for electricity is the same, as it is for generating electricity. Since Prosumers are part of a market segment, they assign economic value to electricity in the same way. Quantification would illustrate that Prosumers earn and spend the same amount of money.
- Architectural decisions. The eco-system at hand requires an IT architecture, to allow for interoperability between all parties. This is not illustrated by the *e³value* model.

5 Conclusion

The question raised at the beginning of the paper is to what extent an *e³value* model can present governance decisions. Concerning value creation, we have learned that *e³value* represents decisions regarding the revenue model. However, partnering of Prosumers can not really be represented in *e³value*, the notion of partnership needs to be revisited, e.g., by introducing different kinds of partnerships. Investments and cost-sharing can be represented if the model is quantified. Coordination of players seems to be more a business process design issue than a business (value) model concern. Roles and responsibilities can be partly represented by value activities; risk and expectations by running what-if scenarios, which is a standard functionality of the *e³value* toolset. An *e³value* model can partly visualize organizational openness and control. Autonomy regarding the decision process can not easily be seen; the distribution of power can be spotted in various ways. Architectural decisions require IT modeling techniques, but also a commitment to standards to ensure inter-operability. As a final remark, although an *e³value* model can represent some aspects of governance decisions, the design process for *e³value* is focused on *business development*: understanding the required eco-system, performing a financial sustainability assessment and fraud analysis. The other layers of the eco-system should be designed and analysed as well (such as control, ICT and powergrid layer). For future research we plan to extend the peer-to-peer *e³value* model and to model the other layers of decentralized governance as well.

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WHAT MAKES IS IMPLEMENTATION SUCCESSFUL? A STUDY ON IMPLEMENTATION EFFECTIVENESS

SASKIA VAN DEN ENDE[1], PASCAL RAVESTEIJN[1] & BENNY M.E. DE WAAL[1]

[1] HU University of Applied Science, Utrecht, The Netherlands e-mail: saskia.van.den.ende@politie.nl, pascal.ravesteijn@hu.nl, benny.dewaal@inter.nl.net

Abstract It has been noted that implementation climate is positively associated with implementation effectiveness. However, the recipe for a successful implementation of IS/IT systems still doesn't exist. Specifically, it is unclear what a "good" implementation climate requires, what it should be, and to what extent the acceptance and success of the implementation of a new IS/IT system is affected. Despite success and opportunities for organizations that innovate with information systems (IS) and information technology (IT) in general there are also many failures of IS/IT implementations caused by both technical and non-technical problems. This study, based on the Klein-Sorra model of implementation effectiveness, shows that skills and innovation-values fit do significantly influence intention to use in the context of our questionnaire-based survey, the implementation of a new document management system (DMS) at the Dutch Police. Survey data was collected from 41 end-users. For practitioners, this research offers practices to be considered during implementation of a new system.

Keywords: implementation climate, implementation effectiveness, information system success, questionnaire-based survey, dutch police.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.25
ISBN 978-961-286-362-3

1 Introduction

While the topic of information systems (IS) implementation success has been the focal point of considerable research, the literature varies regarding how to study an implementation project and what variables determine its success or failure (Larsen, 2003). Despite success and opportunities for organizations that innovate with IS and information technology (IT) (Markus & Loebbecke 2013; Van Veldhoven & Vanthienen 2019) there are also many failures of IS/IT implementations caused by both technical and non-technical problems (Mclean, Antony & Dahlgaard 2017; Pan 2005). Reasons for a successful or failed IS implementation are complex and contested, as different stakeholders and perspectives are involved (Dwivedi et al. 2015). There is relatively little literature available on how these factors can now be governed during the implementation process and how in that light factors interrelate (Jacobs, Weiner & Bunger 2014; Muntslag 2001).

Police organizations have a long history in which they embraced new technologies to improve the efficiency and effectiveness (Koper, Lum & Willis 2014) and it is still an important driver to innovate and improve (Byrne & Marx 2011). However, in essence within the Dutch police the work is not changed very much over the past ten years. Technological developments have shown no changes in existing routines, processes and concepts (Terpstra et al. 2013). New technological innovations have been developed to prevent crime and to improve the performance of the police, but we know remarkably little about how and why (or not) certain innovations are adopted (Byrne & Hummer 2017). The main objective of this study is to offer new dimensions in research into possible interventions in IS-implementation and thereby provide insights into factors that can be managed to improve implementation effectiveness in digitization projects.

In the next section the concepts of this research are discussed and operationalized. After that, the research methodology is described followed by the results of this study. Finally, the conclusions and recommendations for further research are provided.

2 Theoretical Foundation

Implementation is a critical gateway between the decision to adopt innovation and the routine use of the innovation within an organization (Klein & Sorra 1996). For implementation to be a success, the application should be no longer perceived as something new, and the "targeted employees use a given innovation consistently and well" (Klein & Sorra 1996). Markus & Mao (2004) define system implementation success as a high-quality process of preparing the target user community for use of the system (often called "change management") and/or a high quality "change" outcome, namely that the intended users (regardless of whether they participated in development) adopt the system, use it as expected, and/or use it with the desired effects. Change creates a sense of uncertainty and lost control, and employees' resistance and lack of support are some of the most cited causes for failures associated with organizational change (Blut, Wang & Schoefer 2016). This resistance represents a major barrier to changing the behaviors of organizational members to use the innovation and for the organization to reap its benefits (Hwang, Chung, Shin, & Lee 2017). To solve this issue an area of IS research consists of theories and models that are oriented towards the acceptance and use of IS (cf. Venkatesh, Morris, Davis & Davis 2003). These models provide an important theoretical foundation for studying how various users, and technological and environmental influences, can predict, explain and determine the use of IS. From these studies it is also clear that IS research still needs to better address and identify organizational mechanisms and means through which management can influence users' beliefs and attitudes towards adopting new information systems, hence reducing the possibility of failure (Venkatesh et al. 2003).

2.1 The Klein-Sorra-model

A predictive model which pays close attention to the specific factors that have an influence on the effectiveness of the implementation is the Klein-Sorra model (Klein & Sorra 1996). Implementation is "the process of gaining targeted organizational members' appropriate and committed use of an innovation" (Klein & Sorra 1996, p. 1055). They define implementation effectiveness as "quality and consistency of targeted organizational members' use of an adopted innovation" (p. 1056), and is determined by implementation climate and innovation-values fit. Implementation climate is described as "employees' shared perceptions of the events, practices, and behaviors that are rewarded, supported, and expected in a setting" (p.1060). It is formed by (a) users' skills to use the system, (b) incentives for using the system and disincentives for avoiding system use, and (c) removing obstacles to system use.

Innovation-values fit is described as "the extent to which targeted users perceive that use of the innovation will foster the fulfilment of their values" (p.1063).

2.2 IS System success

Regardless of whether the economy is booming or busting, organizations want to ensure that their investments in information systems (IS) are successful (DeLone & McLean 2016). As information systems have become more complex, so has the evaluation of the effectiveness or success of the system (Petter, DeLone & McLean 2012). From an IS perspective, acceptance and system use have been the variables of choice for measuring success (Delone & McLean 2003, 1992). DeLone & McLean proposed a taxonomy of six interrelated variables to define IS success: System Quality, Information Quality, Use, User Satisfaction, Individual Impact, and Organizational Impact. Since the original publication of their model in 1992, researchers have investigated, modified, or extended the concept of IS success (Dwivedi et al. 2015; Petter, DeLone & McLean 2013; Seddon et al. 1999). In fact, both the original version of D&M of 1992 and its extension in 2003, appear among the most cited articles of the discipline in the past decade (Stein & Galliers 2014). In our study System implementation success (i.e., one of the dependent variables) was measured using the concepts of intention to use and user satisfaction. Some papers have shown that the changes of the nature of technology could influence the interaction between technology and its users, thus changing the model that represents that relationship (Mardiana, Tjakraatmadja & Aprianingsih 2015). Because actual use was mandatory and this study was on the deployment of a new Digital Police Dossier (DPD) system, actual use was not included as dependent variable. To many other practical factors such as technical implementation problems and other delays made this measurement less valid. Also the variable Net Impact is not included in the conceptual model. As this was a study of the deployment of a new DPD system during the time of data collection, the measurement of actual Net Benefits as such becomes an irrelevant factor. The quality variables were not included because the focus of this research was on the evaluation of the deployment of a specific application (the DPD system).

2.3 Attitude toward the system

When an organization mandates use, attitudes will likely take on heightened importance and thus warrant consideration (Brown et al. 2002). Mandatory use in the context of our study is that the decision to proceed with the development and use has been made by the management. In mandated environments attitudes might not align with actual behavior, that is, an employee might hold a negative attitude toward adopting the new system, but will ultimately use the system because he/she has to and no other options exist (Hwang, Al-Arabiat & Shin 2016). Users who do not wholeheartedly accept the innovation can delay or obstruct the implementation, and resent, underutilized or sabotage the new system (Markus & Mao 2004). Brown et al. (2002) believe these reactions are a result of the positive or negative attitudes employees form toward the technology. Attitude has been extensively studied as a predictor to Intention to Use, Use, and to lesser extents, User Satisfaction and Individual Impact (Petter et al. 2013) These findings are consistent with well-known past reviews of the literature that found moderate support for the relationship between attitudes toward technology and overall IS success, with most studies supporting this relationship (Petter et al. 2013). In the Hartwick & Barki model (1994) Attitude toward the System is a dependent variable of user participation. In our study attitude is our third dependent variable to the implementation climate variables.

2.4 Conceptual model

Now that we have explained the variables of implementation climate and IS system success, and clarified the importance of attitude towards the system, the integrative conceptual research model of this study is illustrated in Figure 1.

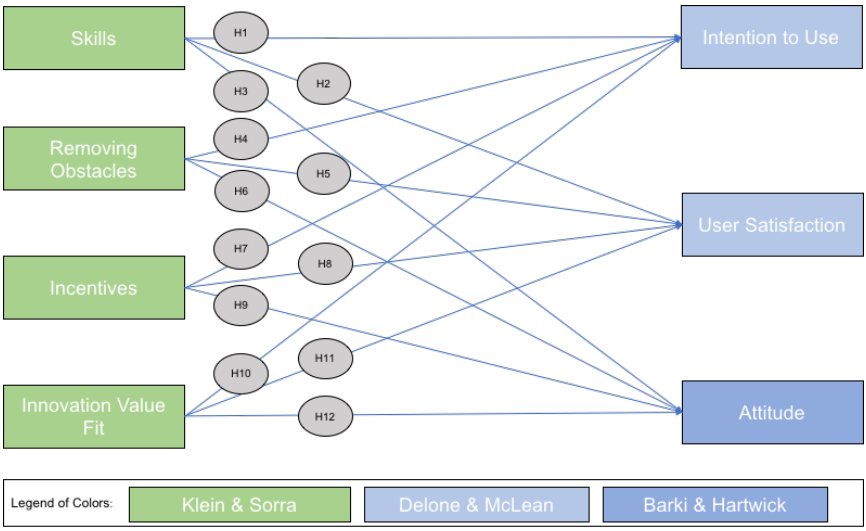

Figure 1: Conceptual model.

The model demonstrates that skills, absence of obstacles, incentives and innovation value fit can be considered as independent variables, while intention to use, user satisfaction and attitude towards the system can be considered as a dependent variable. As such the following hypotheses were postulated and tested.

Skills De Waal & Batenburg (2012a) appoint that studies show a positive effect with respect to users training and implementation success, at the same time they appoint that surveys show that the relationship with users training and implementation success is far more complex than the results suggest. Providing training influences System Usage because it contributes to trusting the new system and contributes to User Satisfaction (Guimaraes, Staples & Mckeen 2003). Knowing users' attitude towards computers and innovations might be a key to successful implementations as it would help recognize how users feel about the new system (Hwang et al. 2017). Building on these explanations the following hypotheses were tested:

H1: Skills is positive associated to Intention to Use
H2: Skills is positive associated to User Satisfaction
H3: Skills is positive associated to Attitude

Absence of Obstacles. Venkatesh & Brown (2001) have uncovered that offering resources and necessary technical support reduces knowledge and resource barriers. Other researchers have found that users can also be motivated through the use of rewards and the provision of training (Igbaria, Guimaraes & Davis 1995)**.** The value of technology appears to differ depending on the tasks of the user and whether the system is perceived to assist or hinder them in the performance of their tasks (De Waal & Batenburg 2012b). Hence:

H4: Absence of Obstacles is positive associated to Intention to Use
H5: Absence of Obstacles positive associated to User Satisfaction
H6: Absence of Obstacles is positive associated to Attitude

Incentives. Klein & Sorra (1996) use the shorthand phrase 'implementation policies and practices' to refer to the array of strategies that organizations put into place to promote innovation use. Engaging expected users and supporters in decision making about innovation design and implementation, providing incentives for innovation use, and providing feedback on innovation use, all enhance motivation. Also, organizations should make the innovation easily accessible or easy to use, give expected users time to learn how to use the innovation, and redesigning work processes to fit innovation use (De Waal & Batenburg 2014). Based on these findings:

H7: Incentives is positive associated to Intention to Use
H8: Incentives is positive associated to User Satisfaction
H9: Incentives is positive associated to Attitude

Innovation Value Fit.

When an individual employee experiences innovation-values fit, they will be drawn to internalize and embrace the system (Klein & Sorra 1996) A study on ERP systems by (Osei-Bryson, Dong & Ngwenyama 2008) suggest that high innovation-values fit influences users to obtain better skills, perceive less obstacles, and feel more motivated in using the new system. A possible explanation is that if users perceive that the new system will help them solve their work related problems; they internalize the benefits of the new system and consequently, they are more open to

learning and mastering the system, thus becoming intrinsically motivated (Osei-Bryson et al. 2008). Some studies have found that when system usage is not intrinsically driven, it suffers underutilization or users' intentional sabotage (Markus & Keil 1994). When 'higher level of intrinsic motivation typically leads to willingness to more time on the task' (Venkatesh 2000), it is more likely that users experience a higher values fit, they are more skilled and motivated to use the new IS. Therefore, the following hypotheses were tested:

H10: Innovation Value Fit is positive associated to Intention to Use
H11: Innovation Value Fit is positive associated to User Satisfaction
H12: Innovation Value Fit is positive associated to Attitude

3 Methodology

3.1 Data collection

We applied a survey to measure all elements of our conceptual model to gain an understanding of the implementation context and practice of the questionnaire-based survey. The survey was carried out during the implementation of the DPD-system in May – June 2019. Participation in the study was anonymous and therefore data was anonymized so it is not traceable to the individual participant.

3.2 End-user survey

The survey was conducted using a web-based tool provided by the Police Academy. All 90 employees who finished their training and joined the pilots were personally asked to take part of the survey. In total 41 respondents completed the questionnaire indicating a response rate of 45%. The participants were located in five units: South-West, West, East, South-East and Midlands. Their function categories were reporter, file-owner or another function, such as implementation supervisor or command duty officer. Most respondents, 54% work in unit South-West. In this unit 47% worked as reporter, 41% as file-owner and 12% have another function. In the unit West the percentage is divided exactly between reporter (50%) and file owner (50%). In unit East and South-East respondents only work in the function 'other'. In unit Midlands 13% of the respondents work as file owner, 6% as reporter and 81% had another function.

3.3 Instrument validation

The questionnaire was designed to measure all elements of the conceptual model. The purpose of the questionnaire was pre-tested for clarity and comprehension by using a small test panel of 5 implementation managers, and 1 communication officer. Comments and corrections were discussed if necessary and incorporated. The items in the questionnaire include scales that are proved to be reliable and valid in previous studies. The items however were adapted to the context of the organization so that they were suitable for testing the hypotheses from the conceptual model. The four constructs Skills, Absence of Obstacles, Incentives, and Innovation-Values Fit, were measured by 26 items from a previous study by Osei-Bryson, Dong, & Ngwenyama (2008). The 'intention to use' construct was measured by one item only: 'If the system was not mandatory, I would still use it' as suggested by Seddon & Kiew (1996). To measure user satisfaction, the information satisfaction and service satisfaction items developed for the different constructs by Shaw, DeLone, & Niederman (2002) were used. Attitude toward the system is measured with four items of the survey instrument developed by Hartwick & Barki (1994). All items of the questionnaire could be answered on a 5-point rating Likert scale (1= fully disagree, 5= fully agree). In order to validate the measurement of the constructs, factor analysis was performed to analyze the construct validity of the items. For all constructs, principal component analysis (PCA) with Varimax rotation and Kaizer normalization was used. The results are presented in Table 1.

Table 1: Factor Analysis and Reliability of Construct Scales

Construct	Number of items	Own value(s)	Explained variance (%)	Cronbach's alpha
Skills	7	3.8; 1.2	54; 17	.856
Absence of Obstacles	2	2.6	65	.820
Incentives	4	1.8	91	.887
Innovation Value Fit	13	5.2; 2.4; 1.5; 1.1	40; 18; 11; 8	.845
Intention to use	1	n/a	n/a	n/a
User satisfaction	8	3.3; 2.5	41; 32	0.865; 0.861
Attitude towards system	4	2.9	72	.872

As can be seen in Table 1, the own values were between 5.2 and 1.1, accounting for 91% to 65% of the explained variance. The reliability of the scales was confirmed by Cronbach's alpha value of 0.887 to 0.820 (cf. Nunnally & Bernstien 1994).

4 Results

In this and the next section we will describe the results of the user survey and the interviews. The main results of the survey are represented in Figure 2 and 3. The regression analysis provided the standardized path coefficients, p-values, and variance explained. The results from Figure 2 show that:

- Skills holds a significant correlation ($r = .69$; $p < .,01$; $N = 41$), with intention to use, which confirms hypotheses 1.
- Skills holds a significant correlation with user satisfaction ($r = .43$; $p < .05$; $N = 41$), which conforms hypotheses 2.
- No significant correlations were found between skills and attitude.
- Absence of Obstacles holds a significant correlation with Intention to use ($r = -0.53$; $p < .001$; $N = 41$), which conforms hypotheses 4. An explanation for the negative value is that a high value of the variable, thus experiencing a low level of Absence of Obstacles by the user, occurs with a high-value of Intention to use.
- Incentives holds a significant correlation with attitude ($r = .39$; $p < 0.,05$; $N = 41$) and incentives holds a significant correlation with intention to use ($r = 0.41$; $p < .01$; $N = 41$), which conforms hypotheses 9.
- Innovation value fit holds a significant correlation with user satisfaction ($r = .51$; $p < 0.01$), which conforms hypotheses 11.
- Innovation value fit holds a significant correlation with attitude towards the system ($r = .40$; $p < .05$; $N = 41$) and also innovation value fit holds a significant correlation with intention to use ($r = .72$; $p < .01$; $N = 41$), which conforms hypotheses 12.

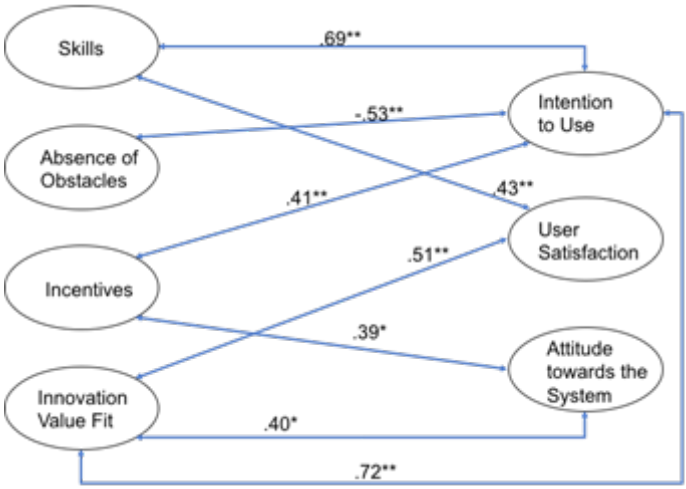

Figure 2: Correlations.

Three multiple regression analyses (method Stepwise) were conducted to examine to what extent the influence of the independent factors was on one dependent factor. Figure 3 shows the relationship between the independent variables Skills, Absence of Obstacles, Incentives and Innovation Value Fit and the three dependent variables of Implementation success. The significant (standardized) regression (beta) coefficients are represented by the one-way-directed arrows in the figure. As the OLS regression model was applied, the potential problem of multicollinearity was investigated by computing VIF factors for each predictor in the regression model. Although in some cases correlations between independent variables were relatively high, VIF factors in none of the models exceeded 5 – a commonly applied rule of thumb (Hair et al. 1998). The results from Figure 3 show that:

- Skills and Innovation Value Fit holds a significant relationship with Intention to Use. The explained variance (adjusted R^2) of the regression model is relatively high: 55.9% (F=26,400, df=40, p=.000).
- only Innovation Value Fit holds a significant relationship with User satisfaction. The explained variance of the regression model is relatively low: 23.6%: (F=13,354, df=40, p=.001).
- also Innovation Value Fit holds a significant relationship with Attitude towards the System. The explained variance however is low: 13.1% (F=7,049, df=40, p=.011).

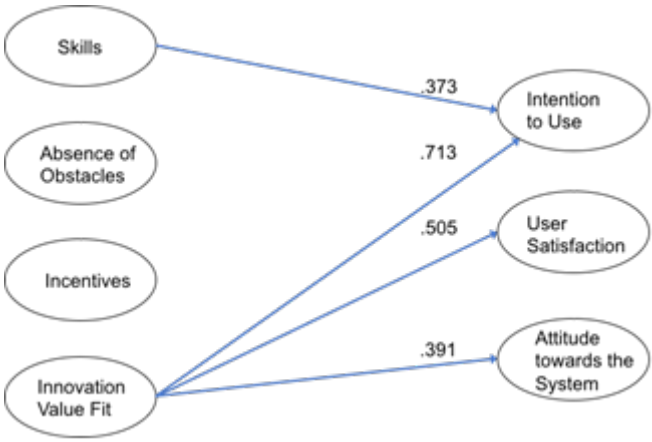

Figure 3: Regression analysis.

5 Discussion and Conclusion

This study aimed to offer insights into factors that can be managed to improve implementation effectiveness in digitization projects. Based on a literature study a conceptual model was developed from which 12 hypotheses were derived. However, not all of the hypothesized relationships were confirmed. The study revealed that Innovation Value Fit does have a strongest relationship with *Intention to Use* and User *Satisfaction* and *Attitude towards the System*. The main contribution of this study is that these findings are used to complement the implementation plan for the upcoming releases. The results do offer insights that can be managed to improve implementations effectiveness in digitization projects at the Dutch police, which ultimately drive success.

Although the research was designed carefully, there are some limitations to this study. First of all, this research is limited one case organisation. The question is whether there is an organization comparable to the Dutch police. Second, the sample size is relatively small. This had to do with the progress of the program in which delay arose (cannot remove Absence of Obstacles) which meant postponement for further implementation of the new DPD. Another limitation is that the study is a specific implementation of DPD. IS implementation research show that IS implementation studies are context-sensitive, making it a topic of concern when it comes to the generalizability of results. A suggestion for further research is a study which consists of multiple cases and could provide additional insight in the causal

relationships between the variables of the conceptual model. Furthermore, research could be executed by extending the conceptual model with additional critical success factors, such as management factors, user characteristics, the degree of user participation, etc. The last suggestion for further research relates to the interpretation and use of the results of the study. Further research could answer the question on how the results of this study can be brought into practice and what impact it will have.

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CROWDFUNDING SUCCESS FACTORS: A STATE-OF-THE-ART ANALYSIS

SCHULZ MORITZ[1]

[1] University of St. Gallen (HSG), Institute of Information Management, St. Gallen, Switzerland, e-mail: moritz.schulz@unisg.ch

Abstract Over the last few years, crowdfunding has gained attention as an alternative source of funding for a variety of projects. Increasing numbers of creative, artistic, and entrepreneurial projects search for funding from the crowd. Although first variables with impact on a project's funding success have been identified, a comprehensive understanding towards creating successful crowdfunding projects remains unclear. This paper analyzes the existing body of knowledge regarding crowdfunding success factors. As a result, we propose a fundamental framework with four dimensions to structure the existing insights of crowdfunding success factors and derive a research agenda to guide further research.

Keywords: crowdfunding, success factors, literature review, art analysis, research paper.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.26
ISBN 978-961-286-362-3

1 Introduction

In the last years crowdfunding has become a viable source of funding for a variety of different projects. The roots of this collaborative phenomenon can be found among creative and artistic projects and spread out towards entrepreneurial and profit-oriented projects (Agrawal et al., 2014; Mollick, 2014). In comparison to traditional sources of funding like friends and family, bank loans or venture capital, crowdfunding offers considerable advantages: speed of funding process, risk diversification for and involvement of capital-givers (Kleemann et al., 2008). Successful crowdfunding projects usually have certain characteristics in common: they tell a story, they actively involve capital-givers and offer appealing compensations for funding participation (Agrawal et al., 2014; Manning and Bejarano, 2017; Scheaf et al., 2018). However, in practice crowdfunding projects either "receive all of their money or fail to receive much at all" (Wash, 2013). Current crowdfunding research is mainly focused on conceptualizing and comparing directly observable project characteristics to define variables with influence on the funding success. However, most researchers focus only on certain types of crowdfunding or data from one single platform. Thus, many findings are unstructured, lack generalizability and are difficult to compare or extend.

This paper intends to clear this issue by reviewing existing crowdfunding literature through a structured and systematic literature review following Webster and Watson (2002) and Vom Brocke (2009). The results of this literature review are presented in a proposed framework that summarizes existing research on crowdfunding success factors. Our work contributes to crowdfunding literature by providing a basis for future theory development while elaborating various pathways for future research.

This paper proceeds as follows: In part 2 we will provide the literature review including the definition of the review scope as well as the conventionalization of the topic. Afterwards, our approach towards the literature search and the proposed framework are introduced. Part 3 includes the presentation of our findings and is followed by part 4 that describes and discusses the possible research agenda. After pointing out the limitations of this literature review, the paper is finished with a conclusion that summarizes the results of our work.

1.1 Definition of the Review Scope

The first step of a rigorous literature review is the definition of the review scope for which we follow the taxonomy of Cooper (1988). Table 1 shows the literature review scope. The paper focuses on research outcomes and the applications of crowdfunding success factors (1). The goal of the literature review is to build an integrative (2) overview of the existing body of knowledge to present the state of the art (4) as it addresses specialized scholars (5).

Table 1: Definition of Review Scope

Characteristics	**Categories**			
1. Focus	Research Outcomes	Research Methods	Theories	Applications
2. Goal	Integration	Criticism	Central Issues	
3. Organization	Historical	Conceptual	Methodological	
4. Perspective	Neutral Representation	Espousal of Position		
5. Audience	Specialized Scholars	General Scholars	Practitioners	General Public
6. Coverage	Exhaustive	Exhaustive & Selective	Representative	Central/pivotal

1.2 Conceptualization of the Topic

The results of the literature review are supposed to answer which characteristics of crowdfunding projects have an impact on the funding success of crowdfunding projects. Therefore, this work focuses on crowdfunding and its success factors, in order to fulfill the requirement of a rigor literature review to "provide a working definition of key variables" (Webster and Watson, 2002). In the following part we describe the phenomenon crowdfunding and the funding process.

1.2.1 Crowdfunding

The crowdfunding process usually has three stakeholders: project initiators that seek funding for their projects, capital-givers from the crowd and crowdfunding platforms that act as an intermediary between the two parties. Existing crowdfunding literature defines different types of crowdfunding platforms that are usually systematized based on the offered returns for capital-givers. Following the widespread archetypes of Massolution (2013), we differentiate between equity-

based, lending-based, reward-based and donation-based platforms. Donation-based platforms offer no material or financial rewards. Reward-based platforms offer a non-financial reward, e.g., product samples. Lending-based platforms offer loan-based interest payments. Equity-based platforms offer ownership or equity. These platforms have one thing in common: they can be described as socio-technical systems that support interaction and contributions between the project and capital-givers (Mollick, 2014). The platforms only provide configurable templates for the project initiators. These templates need to be filled and configured accordingly to create trust, attract capital-givers and to overcome unwanted capital-giver behavior.

1.2.2 Funding process

In accordance with the crowdfunding platform, project initiators choose a desired funding goal that is supposed to be reached within a defined time frame. During this time frame projects tend to either receive their defined funding goal clearly or fail to receive a significant amount of contributions at all (Kuppuswamy and Bayus, 2018; Wash, 2013). Consequently, it can be observed that project initiators set up their projects with a trial and error approach. Yet, a complete recipe for successful crowdfunding remains unclear. However, single variables that differ between successful and unsuccessful projects have been identified. This paper continues with our approach of the literature search to structure and analyze these results.

1.3 Literature Search

In order to identify relevant articles and to assure a rigorous and traceable literature search, a systematic literature review was conducted (Vom Brocke et al., 2009). First, a journal search was executed and followed by a database search with keywords. Second, a forward and backward search of citation indexes was conducted (Levy and Ellis, 2006). The journal search is the first step as major contributions are likely to be found in leading journals (Webster and Watson, 2002). For the journal search, leading journals from Information Systems (IS) and Technological Innovation and Entrepreneurship were considered. These included Journal of Management Information System (JMIS), Journal of Business Venturing (JBV), Entrepreneurship Theory and Practice (ETP), Research Policy (RP) and Management Science (ManSci). The following databases were queried: EBSCOhost, Web of Science, ProQuest, ScienceDirect. The keyword search is the core of a literature search.

According to the above defined key variables, the keyword search was conducted in afore mentioned databases. The literature search closed with a forward and backward search. Table 2 shows the search strings and the results of the literature search.

Table 2: Result of the Literature Search per Database

Search String	EBSCO host		Web of Science		ProQuest		Science Direct		TOTAL	
	Hits	Rev.	Hits	Rev	Hits	Rev.	Hits	Rev.	Hits	Rev.
"crowdfunding" AND "success factors"	13	7	17	2	2	2	53	19	85	30
"crowdfunding" AND "success"	23	14	14	11	6	3	58	21	101	49
"crowdfunding" AND "project"	33	11	15	13	6	5	50	24	104	53
"crowdfunding" AND "platform"	67	12	20	14	13	11	48	17	148	54
"crowd" AND "investor"	30	6	13	10	14	1	169	7	226	24
"crowd" AND "funding"	53	9	40	7	0	0	186	9	279	25
"crowd" AND "investing"	2	1	8	6	8	1	166	4	184	12
TOTAL	221	60	127	63	49	23	730	101	1127	247

The literature review identified a total of 28 relevant papers. Considering the publication dates, it is no surprise that crowdfunding is at a comparably early stage of scientific research since crowdfunding in general itself is still an emerging research topic. Apart from one exception, all identified relevant papers were published in 2015 or later. In addition, crowdfunding research is done from strongly varying perspectives (for example: IS, marketing, finance etc.) and recently gained a lot of attention from the scientific community. We established a strong focus on journal papers in order to only review papers with a high-quality standard. Figure 1 presents the publications per year.

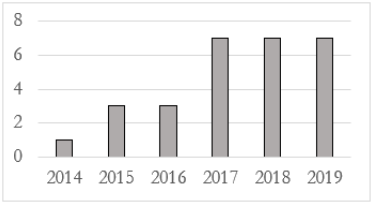

Figure 1: Publications per Year.

In order to synthesize the literature, appropriate categories need to be developed. This paper tackles this issue by developing categories based on existing literature on crowdfunding in general. Based on the fundamental works of Belleflamme et al. (2013) and Mollick (2014), we developed four categories to evaluate the literature based on the perspective of the stakeholders in the crowdfunding process: (1) Crowd or capital-giver perspective: The perspective and behavior of capital-givers plays an important role, since they must take the funding decision towards a project. This category includes all papers with a focus on capital-giver behavior and motivation during the funding process. (2) Platform perspective: As intermediaries the platforms play a central role in the crowdfunding process. This category sums up all papers with a focus on crowdfunding platforms, design requirements and other managerial challenges that platforms face in the crowdfunding process. (3) Project (initiator) perspective: The presented projects that seek funding for their planned activities are essential in the crowdfunding process. Project initiators can present their projects on crowdfunding platforms towards the crowd in order to attract funding from the capital-givers. This category integrates all papers with a focus on the crowdfunding project, project initiators, project characteristics and design principles. (4) Legal perspective: Currently, crowdfunding is facing challenges of changing legal environments (Bhattacharjee et al., 2011; Heminway, 2014). It is very likely that the legal environment also has an impact on the success of a crowdfunding project (Cumming et al., 2019a; Hornuf and Schwienbacher, 2017). Consequently, this category includes all papers that deal with the legal environment of crowdfunding.

2 Findings

In general, it can be said that most of the existing research in the field of crowdfunding success factors strongly focusses on the project as unit of analysis. More than 90% of the investigated literature only used data from one single platform and one specific type of crowdfunding. Additionally, the examined papers mainly focus on directly observable and measurable project characteristics. However, nearly all investigated papers lack a managerial perspective with implications or guidelines for the project initiator to create successful crowdfunding projects. Table 3 shows the detailed results of the literature synthesis.

Table 3. Literature Synthesis

Paper	Type of Crowdfunding	Capital-giver (1)	Platform (2)	Project (3)	Legal (4)
Ahlers et al. (2015)	Equity-based			x	x
Allison et al. (2015)	Equity-based	x		x	
Burtch et al. (2018)	Reward-based		x		
Butticè et al. (2017)	Reward-based			x	
Chan & Parhankangas (2017)	Reward-based			x	
Colombo et al. (2015)	Reward-based			x	
Courtney et al. (2017)	Reward-based			x	
Crosetto & Regner (2018)	Reward-based			x	
Cumming et al. (2019a)	Reward-based		x		
Cumming et al. (2019b)	Equity-based	x		x	
Eiteneyer et al. (2019)	Reward-based	x			
Hildebrand et al. (2017)	Lending-based			x	x
Hsieh et al. (2017)	Reward-based			x	
Jiang et al. (2018)	Lending-based	x			x
Kim & Viswanathan (2019)	Equity-based	x			
Li & Wang (2019)	Reward-based			x	
Mollick & Nanda (2016)	Reward-based	x			
Moss et al. (2018)	Lending-based	x		x	
Oo et al. (2019)	Reward-based	x		x	
Riar et al. (2017)	Equity-based	x			
Saxton & Wang (2014)	Donation-based		x		
Scheaf et al. (2018)	Mixed			x	
Siering et al. (2016)	Reward-based			x	
Stanko & Henard (2017)	Reward-based			x	
Stevenson et al. (2019)	Equity-based			x	
Thies et al. (2016)	Reward-based	x		x	
Vismara (2018)	Equity-based	x			
Walthoff-Borm et al. (2018)	Equity-based			x	

(1) Crowd or capital-giver perspective: Based on our literature review, the perspective of capital-givers from the crowd has been approached by only few scholars. Allison et al. (2015) and Moss (2018) discovered herding behavior based on narratives or the use of certain linguistics in equity-based (Allison et al., 2015) and lending-based (Moss et al., 2018) crowdfunding environments. In addition, Riar (2017), Vismara (2018) and Kim & Viswanathan (2019) showed that, based on their experience level, capital-givers behave different in the funding decision making process and that actions of experienced investors can also initiate herding behavior in equity-based crowdfunding scenarios. Another factor with influence on the funding success of projects in reward-based crowdfunding scenarios is the social capital of project initiators and interaction with capital-givers (Thies et al., 2016; Eiteneyer et al., 2019; Oo et al., 2019). Mollick & Nanda (2016) found that the crowd and designated experts agreed on decisions for funding in the field of arts. In addition to these factors, Cumming et al. (2019b) discovered that in equity-based crowdfunding a higher separation between ownership and control rights is especially important to capital-givers, since it lowers the probability of funding success and the likelihood of attracting professional investors.

(2) Platform perspective: Current literature rarely focusses on the platform perspective and current design principles are mainly driven by practice. A notably examination of reward-based platform characteristics has been done by Burtch et al. (2018). They analyzed the role of the funding mechanism on crowdfunding platforms (i.e. all-or-nothing vs. keep-it-all) and were able to show that the all-or-nothing mechanism (where the project initiator will only receive the allocated funds, if he reached the defined funding goal) leads to a potential reduction in herding behavior. Adding to this platform insights, Cumming et al. (2019a) show the positive impact of platform initiated due diligence checks on reward-based scenarios. They find that due diligence is associated with higher percentage of successful projects, more contributors, and larger amount of capital raised (Cumming et al., 2019a). The characteristics of crowdfunding platforms can also promote herding behavior among capital-givers. Jiang et al. (2018) where able to show the positive influence of the platforms' market share and the cumulative amount funded towards herding behavior. However, the time of operation of a crowdfunding platform is negatively linked with the chances of the herding behavior (Jiang et al., 2018). In addition, they find that government regulatory events weaken the magnitude of the herding effect, suggesting that more information disclosure and stricter operation standards reduce

the value of observational learning (Jiang et al., 2018). Another interesting impulse is set by Saxton et al. (2014) as they show how social networking applications have the potential to step into the classic intermediary role of donation-based platforms.

(3) Project (initiator) perspective: The discovered variables of the presentation of a crowdfunding project reach from its information about risk (Ahlers et al., 2015), through narrative or linguistic details (i.e., specific wording) in the presentation (Allison et al., 2015; Siering et al., 2016; Moss et al., 2018) until its level of innovativeness (Chan and Parhankangas, 2017; Oo et al., 2019). Several authors point out the importance of social capital of a project, especially in the early stage of the funding process, in order to attract the first capital-givers and to gain trust (Colombo et al., 2015; Siering et al., 2016; Butticè et al., 2017). Also, the timing of the pledges plays a central role, as projects with high numbers of participants at an early stage of the funding process turn out to be more successful (Li and Wang, 2019). Interestingly, projects or more precisely project initiators tend to fund their own project, either in the early stage of the funding process or when it comes to closing the gap towards the funding goal (Hildebrand et al., 2017; Crosetto and Regner, 2018). Besides the activities of project initiators, the characteristics of them also has an influence on the funding success of their projects. The prior crowdfunding experience (Courtney et al., 2017), perceived passion (Oo et al., 2019), openness towards the crowd (Stanko and Henard, 2017) and amount of crowd-interaction (Saxton and Wang, 2014; Thies et al., 2016; Scheaf et al., 2018) are variables with positive impact on the project's success. Despite the identified positive and supportive factors, Walthoff-Borm et al. (2018) found that equity-based crowdfunding is often a last resort for a project's funding and offered projects are often less profitable and have higher debt levels than comparable projects in more traditional financial sources.

(4) Legal perspective: Only very few scholars focus on the legal environment of crowdfunding. Based on their identified positive impact of government regulatory events Jiang et al. (2018) suggest more rules on information disclosure and stricter operational standards. Furthermore, Hildebrand et al. (2017) discover that origination fees in lending-based crowdfunding scenarios are bizarrely connected with higher perceived project or loan quality.

3 Discussion

3.1 Research Agenda

Crowdfunding research with focus on success factors is a growing and vivid field of research. Despite a growing number of publications, this literature review reveals three main research shortcomings the published results. First, nearly every identified paper presents results that are based on a single platform analysis. Second, only mostly directly observable and measurable project characteristics have been observed. Third, many of the investigated papers lack operational or managerial perspectives and complementary implications for platforms or project initiators based on the presented results. Considering the complexity and context-sensitivity of crowdfunding we define four research streams based on the findings of our literature review. When defining success factors in the field of crowdfunding, the project itself is an obvious unit of analysis and has been investigated by many scholars. However, detailed insights that reach beyond directly observable or measurable variables are still missing. First steps in this direction have been taken by Chan & Parahankangas (2017) by analyzing the level of innovativeness and its impact on funding success. Another interesting starting point to continue this direction of research can be the application of signaling (Ahlers et al., 2015). For example, the reward-based platform Kickstarter regularly hosts successful crowdfunding projects with extraordinary levels of entertainment, creativity, fun or hedonic value. Future research should address these variables that are known to play a role in the field of traditional finance or banking (i.e. professional investors) in order to define further explanations for funding success.

Another obvious stream of research should address the role of crowdfunding platforms. The crowdfunding platforms play a central role in the crowdfunding process by allowing project initiators to interact with a large number of capital-givers in a (cost) effective manner. First researchers indicate the need for a detailed analysis of platforms in each type of crowdfunding (Saxton and Wang, 2014). As the intermediary, one central task of the platform is to provide access to a crowd of capital-givers. Following this thought, further research should investigate on how platforms can motivate capital-givers to participate in the funding process of projects. At the same time platforms need to attract compelling projects and offer suitable tools to present themselves towards the crowd. Furthermore, the

crowdfunding platforms are responsible for operational processes during and potentially after the funding process (i.e. payout of collected funding), as well as ensuring legal compliance for both project and capital-givers. We propose that further research is needed in order to clarify the different characteristics and directions of crowdfunding platforms.

As stated above, the legal environment of crowdfunding is only analyzed by very few scholars although it is very likely, that legal requirements have direct influence on the funding success of a project (Bhattacharjee et al., 2011; Cumming et al. 2019a). The fast development of the phenomenon crowdfunding could be the reason that only few scholars focus on legal aspects. A first step in this research stream could be a legal grounding of the different types of crowdfunding and comparisons to traditional sources of finance. In addition, the legal requirements or the legal framework for platforms, projects and project initiators (i.e., pre and post funding) and capital-givers (i.e., protection for individual, non-professional capital-givers) provide complex and uncovered areas for future research.

Lastly, the characteristics of capital-givers from the crowd have mostly been defined based on results of analyses of crowdfunding projects. This first approach towards a better understanding of the behavior in the funding decision process should be analyzed further. It is very likely, that not every behavioral variable is measurable through project characteristics and thus, important insights on capital-giver behavior might remain uncovered. As a result, the investigation of capital-givers and their motivation as well as actions beyond taking a funding decision (e.g., social interaction) are interesting fields for future research.

3.2 Limitations

This systematic literature review paper is facing two mentionable limitations. First, only scientific literature was analyzed. As a result, this paper lacks insights from the fast developing and changing practice. Second, only literature with a direct link to the term crowdfunding has been investigated as the search strings only contained "crowd" or "crowdfunding". The area of crowdfunding overlaps with other research streams that have not explicitly been considered (e.g., peer to peer lending, donations). It is likely, that some of the presented key issues are also addressed or enhanced by other research streams and scientific journals. Further research is

needed in order to better integrate these streams with our results and to create a better understanding on success factors in the field of crowdfunding.

4 Conclusion

In summary, the research in the field of crowdfunding success factors is vivid but still limited, despite its potential and advantages in comparison to traditional sources of funding. This literature review presents the existing body of literature on crowdfunding success factors. Our work provides an initial framework with the key perspectives of crowdfunding that helps to further develop a theoretical in-depth understanding of success factors in the field of crowdfunding. Besides, our investigation points out shortcomings of existing research and suggests streams for future research.

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PARADOXICAL BEHAVIOUR IN SOCIAL MEDIA USAGE

RUBEN POST[1], SEBSTIAAN WIEWEL[2], BRIAN JANSEN[2] & STIJN KAS[1]

[1] HU University of Applied Sciences Utrecht, Institute for ICT, Utrecht, The Netherlands, e-mail: ruben.post@hu.nl, stijn.kas@hu.nl
[2] Utrecht University, Faculty of Science, Utrecht, The Netherlands, e-mail: s.o.wiewel@students.uu.nl, b.n.janssen@students.uu.nl

Abstract The Privacy Paradox is a recently emerged phenomenon. It looks at a person's intention to disclose information and the actual disclosure of information. In this research, we look at the extent of the relationship between the social media behaviour of a student and their attitude towards privacy. With these results, we can conclude whether they show paradoxical behaviour. These results are derived from a questionnaire among information technology students (n=126) and analyzed to extract the extent of the relationships between certain variables. The data analysis showed significant relationships between several variables, none of which indicated paradoxical behaviour among the population. However, it did give way to various interesting relationships. The results indicate paradoxical behaviour to a certain extent, specifically with regards to social media use self-disclosure and information and privacy concerns and privacy settings. Additionally, the research indicates that the higher the educational background of the participant, the less likely they are to exhibit paradoxical behaviour.

Keywords: online privacy, social media, paradoxical behavior, research paper, Bled eConference.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.27
ISBN 978-961-286-362-3

1 Introduction

In recent years, privacy has become an increasingly influential factor in consumer decision making (Necley, 2017; Lahlou, 2008). Societal behaviour has become aware of the damage privacy-compromising applications, operating systems, and websites can inflict. However, this also introduced paradoxical behaviour. Specifically, society has a tendency towards privacy-compromising actions which results in a dichotomy between privacy attitudes and actual behavior (Acquisti, 2004). This phenomenon has been dubbed "The Privacy Paradox" (Norberg, Horne, & Horne, 2007; Barnes, 2006).

The need for privacy is becoming increasingly prevalent in our daily lives (Finn & Wright, 2016). However, some seem to value it less than others (Kokolakis, 2017; Dienlin & Trepte, 2015). Additionally, the amount of information that is being collected is increasing also (Hargittai & Marwick, 2016). This might indicate paradoxical behaviour. Therefore, the objective of this study is to measure whether students allow for paradoxical behavior showing in their intentions to limit disclosure and the actual personal details they provide on social media. This problem statement leads to the following exploratory research questions:

RQ1: What is the relationship between social media behaviour and the attitude towards privacy?
RQ2: To what extent does social media behavior and the attitude towards privacy vary between educational groups?

To answer these questions, the results of a questionnaire reporting on the individual's social media behavior and attitude towards privacy are analysed. In turn, from a practical perspective, users of social media should be made aware of their potential contradictory behaviour. From a scientific perspective, literature suggests a need for insight and further research into the phenomenon of the privacy paradox (Necley, 2017; Norberg et al., 2007).

The next section discusses the current state of the research field regarding privacy paradoxical behaviour and the relation of educational groups and privacy awareness. After this, the research method, including the explanation and grounding of the measured variables is described. Next, the results of the research are presented and

elaborated through various visualizations. The last section presents the conclusions and discusses the utilized research method and results of the research, followed by possible directions for future research.

2 Background and related work

To answer the research question several subjects are discussed. The current state of these subjects is discussed along with their relationship to this research.

2.1 Online privacy

Society is spending more time online than at any point in history (Huang, 2017; Nie & Erbring, 2002). With over 7.4 billion internet users, most spending more than 10 hours a week online, online privacy has become as important in our daily lives as offline privacy (Huang, 2017; Nie & Erbring, 2002). The definition of privacy is ambiguous and often difficult to conceptualize (Warren & Brandeis, 1890; Martin, 2016). Hence, it is difficult to derive a definition of online privacy. Due to the relative importance of this definition, this research defines a stipulative definition of a constituent of privacy, namely online privacy, for practical purposes. In this research, online privacy is defined as encompassing the handling of data generated by all user-generated online activity.

In recent years, online privacy has been subject to scrutiny by journalists due to increasing awareness and events that reflect badly on the perception of online privacy (Cadwalladr & Graham-Harrison, 2018; Steel & Fowler, 2010). This scrutiny gave way to increased online privacy concern and awareness among internet users (Antón, Earp, & Young, 2010).

2.2 Social media behaviour

Social media is an industry inherently intertwined with online privacy. However, social media has also becomes intertwined in society, with more than 50% of American adults using social media (Perrin, 2015). However, online behaviour indicates a lack of concern for privacy. The results of Perrin (Perrin, 2015) indicate that internet users have become less concerned with how their personally identifiable data is used. Research of Obar and Oeldorf-Hirsch provide context to these results

by indicating that 99% of social media users (which are also part of the internet users population) accept the privacy policy and terms of services without reading them (Obar & Oeldorf-Hirsch, 2018). When social media behaviour is put in the context of the recent scrutiny surrounding online privacy, it indicates a paradoxical trend. This trend has been dubbed "the privacy paradox" (Barnes, 2006; Norberg et al., 2007).

2.3 Privacy paradox

As privacy awareness increases in our society, we are faced with a difficult and ambiguous challenge. With the introduction of social media, privacy got induced in a previously unknown avenue. This new avenue gave way to services without monetary costs associated with them. However, the price is paid in personal data which is (mis)used by the organizations that exploit these social media platforms (Lomborg & Bechmann, 2014).

This introduction gave society access to free services, and the organizations exploiting these services access to data. In turn, society was faced with a question: How far will you go to make use of these free services? This is where the privacy paradox is introduced: a person might say they value privacy while giving away their data to make use of these services (Barnes, 2006; Norberg et al., 2007). For example, a person may have many concerns about companies always knowing where they are based on geographical data, but also frequently upload geographically-tagged social media posts. This is called paradoxical behaviour. This paradoxical behaviour could lead to uninformed consumers and misuse by organizations.

Current research on the privacy paradox indicates that the privacy paradox is not a symptom of youth, but rather concerns people of all ages (Kokolakis, 2017). It should also be noted that this research only regards social media, but the privacy paradox is prevalent in all industries dealing with personal information (Kokolakis, 2017; Schmitz, 2005).

2.4 Educational based privacy awareness

As previously mentioned, the privacy paradox concerns all ages, and therefore all educational groups (Kokolakis, 2017). Different educational groups might have varying attitudes towards privacy or different social media use. For example, these groups might have trouble reading the privacy terms (Hong, Patrick, & Gillis, 2008). Of course, this would be an extreme case. But on a wider scale, groups are affected by their intelligence, as it relates to context awareness and ability to selfregulate, which in turn influences their attitude towards privacy (Baatarjav, Dantu, & Phithakkitnukoon, 2008).

3 Method

The research method is chosen based on the problem statement of this research. Since the problem statement is addressed through hypothesis, a survey is an appropriate research method (Van Dun, Hicks, & Wilderom, 2017).

3.1 Data collection

In order to answer the research questions, a questionnaire is used. The questionnaire can be requested from the authors. The questionnaire offers benefits such as being able to reach a large group of people and offering structured data that can be used in the quantitative analysis. In this questionnaire, participants were asked to rate different statements, which are defined by the variables, on a Likert Scale. For this study a Likert Scale from 1 to 5 was chosen (Joshi, Kale, Chandel, & Pal, 2015; Dawes, 2008). Additionally, with regards to the validity of the questionnaire, by grounding the independent and dependent variables in previous research, the external validity of the questionnaire is increased.

The questionnaire is distributed through web-based sharing. This choice should not affect the results of our research, but given the time span of the research, it was the most feasible solution. The questionnaire was distributed in the network of the researchers, whilst being limited to students of the Utrecht Utrecht and HU University of Applied Sciences Utrecht. The questionnaire was anonymous and no personally identifiable data was included.

3.1.1 Demographics

The participants are gathered using convenience sampling in which the researchers arbitrarily asked information science students from the Utrecht University as well as HU University of Applied Science Utrecht to participate. Hence, the students of these universities formed the sample and unit of analysis and students of Dutch universities our population. As for the sampling method, convenience sampling is a method often used for research that is applicable to a wide population (Etikan, Musa, & Alkassim, 2016). A total of 126 participants of average age 24.5 answered the questionnaire where 65.9% of the respondents are male (*n=83*) and 34.1% female (*n=43*) across four educational groups. Each participant was asked their gender, age, and education level.

3.2 Independent variables

The questionnaire measured four independent variables: social media use, privacy settings, privacy concerns, and self-disclosure of information. These variables are used to describe how much the participant values their privacy and how much privacy they give up to use certain social media features.

Social media use is measured with a scale developed by Leigh Young & Quan-Haase (Young & Quan-Haase, 2013). The first item asked, "How often do you visit social media applications/websites?" the second item asked, "On average, how much time do you spend on social media?" the third item asked, "How many social media friends/followers do you have?" the fourth item asked, "How many of your social media friends/followers do you consider close friends?" and the fifth and final item asked "How often do you post something on social media?". Participants were asked to rate each question in a category on a scale from 1 through 5.

Self-disclosure of information indicates the extent to which the participant agrees with statements related to the disclosure of information on social media and is developed by both Chen (Chen, 2018) and Taddicken (Taddicken, 2014). The first item asked, "I like to share my personal feelings." the second item asked "When I have something to say, I like to share it on social media.", the third item asked "I always find time to keep my profile up-to-date." the fourth item asked "I keep my friends updated about what is going on in my life.", and the fifth and final item asked

"I often geotag my location.". Participants were asked to score the questions from 1 "Not at all" to 5 "Very often".

Privacy setting measures to what extent people withdraw their information (i.e., limiting profile visibility) and set boundaries about with whom they would like to share personal information (i.e., friending) in order to stay private (Chen, 2018). it also measured with a scale developed by Leigh Young & Quan-Haase (Taddicken, 2014). The privacy settings of a participant are described by their profile and information visibility. The first item asked "Who can view your profile?" and "Have you made any changes to your privacy settings since creating your social media account?". Participants were asked to identify who can view their profile (from "Nobody" to "Everybody") and whether they changed their privacy settings (yes/no).

Privacy concern indicates to which extent participants are concerned about the following when using social media and is developed by Chen (Chen, 2018). The first item asked, "The information I submit on social media could be misused." item two asked, "A person can find private information about me on social media." item three asked, "Submitting information on social media, because of what others might do with it." and the fourth and final item asked
"Submitting information on social media, because it could be used in a way I did not foresee.". Participants were asked to score the questions from 1 "not at all concerned" to 5 "very concerned".

The variables **social media use** and **self-disclosure of information** form the facet "Social media behaviour" and privacy settings and privacy concern form the facet "Attitude towards privacy". This is done by averaging the scores of the participant. These facets are used to answer the research questions.

3.3 Independent variables

The dependent variables for this research are the highest level of education of the participants. The participants were asked to identify their highest level of education at the beginning of the questionnaire. As mentioned in the background and related work, the educational background of a responded might have a relation with the attitude towards privacy, which in turn could affect certain relationships between the

independent variables (Baatarjav et al., 2008; Hong et al., 2008; Kokolakis, 2017). The four education groups are high school, Bachelor (WO), Higher Vocational Education (HBO), and Masters (WO).

3.4 Hypotheses

The following hypotheses are stated:

Hypothesis 1: Social media use negatively affect Self-disclosure of information.

This hypothesis supports RQ1 because it a negative relationship would indicate paradoxical behaviour (i.e. the more a person uses social media, the less information they disclose).

Hypothesis 2: Privacy concerns negatively affects privacy settings.

A negative effect on privacy settings means increasing the information withdrawal set by these settings, i.e. having stricter and more privacy secure settings. This hypothesis supports RQ1 because a negative relationship would indicate paradoxical behaviour (e.g. the more privacy concerns a person has, the more information they give away by not adjusting their privacy settings).

Hypothesis 3: Social media behavior significantly affect attitude towards privacy across the full sample.

The first two hypotheses (H1 and H2) are used as a baseline in order to answer H3, which measures the paradoxical behaviour. These variables are used in previous research, which indicated relations between them (Necley, 2017; Barnes, 2006). H3 allows us to answer RQ1.

Hypothesis 4: Social media behavior significantly affects attitude towards privacy differently between the various educational groups.

The educational groups are the dependent variable because previous research indicated a difference in the attitude towards privacy among different educational backgrounds (Necley, 2017; Barnes, 2006). H4 allows us to answer RQ2.

4 Data analysis

After the data collection, the data was anonymously stored and analysed by the researchers using R, Python, and SPSS. The anonymous data can be requested from the researchers, as it cannot be placed in a appendix due to its size.

4.1 Data preparation

All questions in the questionnaire were mandatory, meaning there were no null-values. To be able to analyse the data, the question "Have you made any changes to your privacy settings since creating your social media account?" has been transformed from the scale "Yes/No" to "1 through 5", with yes representing 5 and no representing 1. The internal validity of the questionnaire varied between variables. The social media use sub-scale consisted of three items ($a = .74$), with "How many of your social media friends/followers do you consider close friends?" being dropped, The self-disclosure of information sub-scale consisted of four items ($a = .67$), the privacy setting sub-scale consisted of two items ($a = .64$), and the privacy concern sub-scale consisted of four items ($a = .86$).

4.2 Statistical tests

To answer hypotheses H1, H2, and H3, correlation is an appropriate test because the hypothesis suggest a relationship between variables. H1 looks for a negative relationship between social media use and self-disclosure of information, H2 looks for a negative relationship between privacy concerns and privacy settings, and H3 looks for any effect between social media behaviour and attitude towards privacy.
Social media use and self-disclosure of information are significantly correlated ($r = .41, p \leq .0001$). Therefore, H1 is accepted. Privacy setting and privacy concern are significantly correlated ($r = -0.29, p \leq .001$). Therefore, H2 is accepted. There was a non-significant correlation ($r = -0.02, p = n.s.$) between social media behaviour and attitude towards privacy. Therefore, H3 is not accepted.

H4 was answered using a Multivariate analysis of variance in the form of Pillai's trace because the assumption of homogeneity of variance- covariance is violated in the data. H4 looks for a difference between the effect of social media behaviour and attitude towards privacy between four educational groups. The multivariate result was significant, (Pillai's Trace = .07, F = .22, df = (2), p = .01), indicating a significant difference in social media behavior and attitude towards privacy between High school and Bachelor (WO) graduates. Additionally, the multivariate result was significant, (Pillai's T race = .11, F = 4.25, df = (2), p = .05), indicating a difference in social media behavior and attitude towards privacy between Higher Vocational Education (HBO) and Bachelor (WO) graduates. Lastly, the multivariate result was significant, (Pillai's Trace = .09, F = 2.78, df = (2), p = .01), indicating a difference in social media behavior between Higher Vocational Education (HBO) and Masters (WO) graduates. Based on these tests, H4 is accepted.

5 Results

In sum, the research found two significant relationships. The data analysis accepts both H1 and H2, indicating that the more a person uses social media, the less information they disclose and the more privacy concerns a person has, the more information they give away by not adjusting their privacy settings. These results are especially interesting because by accepting H1 and H2, the research indicates paradoxical behaviour (e.g., the participants say that are worried about the misuse of their data, but do not adjust their privacy settings to reflect this concern). However, by accepting H1, this research does not indicate a significant relation between social media behaviour and attitude towards privacy. Therefore, this research can conclude that the privacy paradoxical behaviour is evident in the sample, but not to the full extent that has been hypothesized. H3 was rejected, indicating that there is no significant correlation between social media behaviour and attitude towards privacy. Additionally, H4 was accepted, indicating that participants with a higher educational background show less paradoxical behaviour with regards to privacy. It should be noted that the nature of the data can only answer the hypotheses. It cannot conclude a causal relationship between the aforementioned variables.

6 Conclusion

During this research, we aimed to find an answer RQ1: **"What is the relationship between social media behaviour and the attitude towards privacy?"** To answer this question, 126 participants filled in a questionnaire. The data these questionnaires provided has been analysed to conclude that there is a non- statistical relationship between social media behaviour and the attitude towards privacy. Additionally, the data was used to answer RQ2: **"To what extent does social media behavior and the attitude towards privacy vary between educational groups?"** The data analysis concluded that the higher a participants educational background, the less likely they were to exhibit paradoxical behaviour.

With regards to previous research, this research confirms the results of both Norberg and Horne (2007) and Young and Quan-Haase (2013) to a certain extent. It confirms the existence of paradoxical behaviour, but does not show a significant relation between the variables measured in the stated previous research (see results of H3). This might be due to the limitation of this research (see section 6), but could have other reasons unknown to the authors.

From a practical perspective, the results of this questionnaire could provide educational material for policymakers regarding privacy and security law. From a scientific perspective, this research adds to the body of knowledge regarding privacy-related behaviour.

7 Limitations and future research

The research has several limitations. First, regarding the sample, all participants are following courses that have information technology as a focal point. This could mean that the students could be biased towards the potential danger of information technology. Even though the internal reliability of the questions was acceptable, generalizing the statistics to the population might not be feasible. However, to conclude the effect this might have had, future research should be done that includes other courses that do not have information technology as a vocal point.

Second, regarding the sample size, the study has a total sample size of 126. This is regarded as a high enough sample to conclude potentially statistical significant relations. However, a higher sample size could show various other significant relations between the variables and educational groups. Specifically, the increasing the sample size per educational group could provide additional insight, as a larger sample size may have indicated additional significant differences.

Furthermore, future research should consider reproducing this research with a different sample and a potentially bigger sample size. Additionally, future research could focus on the effects of privacy paradoxical behaviour among students and whether it opens them up for potential dangers. This could provide useful insight for policymakers and increase the awareness of the importance of online privacy among students as well as all internet users.

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THREE ISSUES WITH THE STATE OF PEOPLE AND WORKPLACE ANALYTICS

JOSCHKA A. HÜLLMANN[1] & JANA MATTERN[1]

[1] University of Münster, Business School, Münster, Germany,
e-mail: huellmann@uni-muenster.de, jana.mattern@wi.uni-muenster.de

Abstract People and workplace analytics is a hype topic. It depicts information systems and processes for data-driven decision-making that concern people-related organizational outcomes. The topic is driven by practitioners with only scarce academic backing. We outline three challenges for the field of people and workplace analytics: first, ambiguity in definitions and conceptions, second, sparse research as well as a lack of scientific evidence for the espoused value propositions, and third, a lack of strong theoretical foundation. To address these challenges, we propose a categorization schema, grounded in existing research on management information systems and tailored to people and workplace analytics. The schema helps to identify the prevalent conceptions on people and workplace analytics, and to clarify the elicited gaps in understanding.

Keywords: people and workplace analytics, issues, conceptions, categorization, state of people.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.28
ISBN 978-961-286-362-3

1 Introduction

In the year 2013, the movie "Moneyball" prominently depicted data-driven people decisions in baseball. Based on the work of Billy Beane and the so-called "Sabermetrics" the trend towards analytics in sports has seen a peak in the year 2019 with the team Liverpool F.C. winning the Champions League—at least partially attributed to Ian Graham, their people analyst (Schoenfeld, 2019). At the same time, the advancement of digital technologies led to the era of big data, with a widespread adoption of analytics in various domains and business functions (McAfee & Brynjolfsson, 2012). Organisations, and in particular human resource management, see prospects for data-driven people management beyond mere reporting and controlling. Inspired by the movie "Moneyball", Ben Waber coined the term "people analytics" and popularized analytic methods that seek to scrutinize and improve people's work practices and people decisions in organisational settings (Waber, 2013). A well-known adopter of such methods is the company Uber, which makes heavy use of analytic models and nudges to influence their drivers' behaviour, e.g. persuading them to service high-demand urban areas (Möhlmann & Zalmanson, 2017).

Concomitantly, the hype surrounding people analytics is growing with newspapers, consultancies, software vendors, and influencers singing a steady and sibilant buzz alike. For introducing **people and workplace analytics**, we tentatively define it as a "*socio-technical system and associated processes that enable data-driven (or algorithmic) decision-making to improve people-related organisational outcomes*". The objective of people and workplace analytics are insights about people behaviours and prioritising data-driven (predominantly quantitative and big data, but also qualitative data) decisions over intuition (Levenson & Pillans, 2017).

In this manuscript, we address the research question how people and workplace analytics is understood and conceptualized in academia and practice. Accordingly, we briefly outline the hype and state of the people and workplace analytics field based on a literature review (cf. appendix). We discuss three challenges of the field and contribute a categorization schema to capture the diverging conceptions prevalent in the field. Subsequent research can use this schema to address the discussed challenges and advance our understanding of people and workplace analytics.

2 Hype – The Growth of People and Workplace Analytics

In 2003, Waber published his book on people analytics, spawning a plethora of publications during the last decade (Tursunbayeva et al., 2018). The increase of publications coincided with the trend towards big data and analytics. In their Harvard Business Review article McAfee and Brynjolfsson (2012) dub big data the "management revolution", while Chen et al. (2018) describe how organizations derive value from big data through business intelligence and analytics. Originating in disciplines such as marketing, sales, and finance, the investments into analytics for human resources and people related business functions are growing (Gal et al., 2017). Based on such analytics, proponents of people and workplace analytics seek insights into people-related organisational outcomes from basic metrics over performance indicators to multivariate statistical analyses (Levenson, 2018).

Driven by the available data (Davenport et al., 2010) and novel cloud capabilities (Guenole et al., 2015), 69% of enterprises with more than 10,000 employees have a people and workplace analytics team (Chakrabarti et al., 2017). People and workplace analytics is seen as a high priority by 71% of the companies (Agarwal et al., 2018) and 79% established data analyst roles for people-related business functions (Society for Human Resource Management, 2016). Stratistics MRC estimate the global market value for people and workplace analytics at USD 429 million in 2015 (Levenson & Pillans, 2017). Despite the growing interest, many organisation do not consider themselves at a mature level of people and workplace analytics operations (Levenson & Pillans, 2017).

Practitioners—vendors and consultancies in particular—put people and workplace analytics on their agenda: "*HR analytics is one of the hottest trends in the context of HR strategy and decision making. Big data in organizations is overwhelming*" (Falletta, 2014). Start-ups are founded, conferences organized (e.g. PAFOW, People Analytics and Future of Work), and expertise offered. Typical promises include the improvement of turnover, retention, recruiting, and workforce planning (Chen et al., 2018; Visier, 2018) as well as employee engagement and empowerment (Davenport et al., 2010). Beyond improving operations, proponents see the opportunity for people and workplace analytics to provide competitive advantage (Hoffmann et al., 2012) and strategic guidance (Isson & Harriott, 2016; Lawler & Boudreau, 2015). The promise

of objectivity for rigorous people-related decision-making ought to give the human resources function a strategic role in the board (Fecheyr-Lippens et al., 2015).

3 Three Challenges

Despite the hype, the academic community has yet to dive deep into the topic and deliver critical guidance. As an emergent trend, we see three major issues with the state of people and workplace analytics that need to be addressed based on our literature review (cf. appendix). First, the ambiguity in terminology and definition, with authors employing varying and conflicting conceptions of people and workplace analytics, leads to an elusive understanding and blurry boundaries of the phenomenon. Second, the sparse research and a lack of scientific evidence means there is no empirical backing for many claims of positive outcomes of people and workplace analytics. Third, the current state of people and workplace analytics suffers from a weak theoretical foundation and misses an inquiry into potential side effects and unintended outcomes

3.1 Ambiguity in Terminology and Definition

In the current debate on people and workplace analytics, we find different terms used interchangeably by practitioners and academics, including but not limited to workplace analytics, people analytics, human resource analytics, and workforce intelligence, with the dominant terms being people analytics and human resource analytics in the last ten years (Tursunbayeva et al., 2018). On the one hand, different terms may subsume the same underlying conceptions; on the other hand, the same term may refer to different conceptions—ultimately leading to ambiguous use and understanding of the terms.

In the academic literature for instance, Shrivastava et al. (2018, p. 3) indicate that people analytics corresponds to human resource analytics: "*people analytics or human resource (HR) analytics refers to [...]*". Conversely, the definitions of people and workplace analytics by Cheng (2017) and by Singer et al. (2017) show conflicts. While the former states people and workplace analytics is about "*strategic influence in human resource management*" (p. 2), the latter aims at "*improving collaboration*" (p. 125) between people. Another example is that Cheng (2017, p. 2) defines people and workplace

analytics as "*a tool*", whereas Marler and Boudreau (2017, p. 15) define it as "*a human resource practice*".

We find similar variation in the practitioners' literature. Guenole et al. (2015) argue that people and workplace analytics is only concerned with human resource data, processes and outcomes, while workforce (mind the different word) analytics refers to the general workforce and aims at improving performance. Sinar et al. (2018) advance a similar definition for the term people and workplace analytics that aims at the "*[...] quantification of the people drivers of business outcomes, with the purpose of making better decisions*" (p. 52).

The ambiguity of terms is exacerbated by vendors offering different services and solutions (or tools) under the same terms, e.g. one vendor may use "workplace analytics" to refer to a particular solution (e.g. Microsoft), while another vendor may use "workplace analytics" to refer to their consulting service (e.g. IBM). The underlying methodological approach and the targeted organisational outcomes vary between vendors and their services and solutions, thus, adding to the confusion. The ambiguity in terminology by academia, practitioners, and vendors mirrors the diverse landscape of definitions, and services associated with people and workplace analytics. While a clear overview is lacking, a single definition does not resolve this issue—and cannot be reasonably found. Different actors solve different problems in different contexts using the term people and workplace analytics. Hence, we suggest identifying the prevalent conceptions of people and workplace analytics to organize the field.

3.2 Sparse Research and Lack of Scientific Evidence

People and workplace analytics "*is going mainstream*" (Arellano et al., 2017, p. 1). However, the trend is criticized as being ephemeral, "*resembling a hype more than substance*" (van der Togt & Rasmussen, 2017, p. 128). The topics are being discussed without a prominent impact in the field (Rasmussen & Ulrich, 2015), suffering from consultancies and software vendors looking at commercial opportunities that provide only little value to prospective organizations (van der Togt & Rasmussen, 2017). According to Cheng (2017), this has caused organisations to engage in people and workplace analytics without an assessment of their own needs. A better understanding on what people and workplace analytics constitutes, what business

problems it addresses, and how it adds value is needed (Angrave et al., 2016; Gal et al., 2017).

There is an abundance of practitioners' literature, blog entries, whitepapers, and consulting reports, as well as software vendors offering solutions for people and workplace analytics, generating a buzz in in the people and workplace analytics market with a focus on (off-the-shelf) tools, descriptive reporting and prescriptive guidelines (Angrave et al., 2016). However, the cost-benefit for these services is unclear (Cascio & Boudreau, 2011). The solutions offered are too generic, not customized, and not tailored to the specific organizational case (Angrave et al., 2016; Boudreau & Ramstad, 2007).

The paucity of scholarly work on people and workplace analytics illustrates that the academic management community has shown little importance to people and workplace analytics so far (Marler & Boudreau, 2017). However, scholars do start to take interest (Gal et al., 2017; Tursunbayeva et al., 2018) and Marler and Boudreau (2017) provide an early literature review for the human resources field. The few existing scholarly articles criticize that people and workplace analytics does not live up to its hype with many failed projects (Rasmussen & Ulrich, 2015). Empirical research is scarce and the espoused value propositions of people and workplace analytics lack scientific support (Marler & Boudreau, 2017). Side effects and unintended outcomes of people and workplace analytics are not investigated sufficiently (Gal et al., 2020). Others question the effectiveness of data-driven decision-making amidst bias and a lack of fairness, because algorithms are designed and implemented by humans (Ebrahimi et al., 2016; Zarsky, 2016). Nevertheless, it is suggested that, under the right circumstances, people and workplace analytics may have positive effects on organisational outcomes (Marler & Boudreau, 2017). For example, one empirical study by Aral et al. (2012) found a positive association between people and workplace analytics and organisational performance.

3.3 Lack of Strong Theoretical Foundation

While Tursunbayeva et al (2018) provide a scoping review across different terms and attest an increasing scholarly interest, they do not contribute to a theoretical understanding of the phenomenon. Marler and Boudreau (2017) published a literature review in the human resources field, where they primarily identified

academic reviews and opinion pieces as well as practitioners' whitepapers with descriptive statistics, concluding that people and workplace analytics needs a stronger theoretical underpinning. Theoretical warrants on how people and workplace analytics generates value are lacking. Concerns regarding operationalization and measurement are not discussed. Big data or digital traces do not provide the "objective" truth that is being sought (e.g. Hüllmann & Krebber, 2020). The data is oftentimes collected without context, manipulated and shaped by the people being observed (Østerlund et al., 2020; Pachidi et al., 2016). Hence, such data—like other performance data—presupposes underlying theory to be interpreted, as well as a careful consideration of construct validity (Howison et al., 2010; Hüllmann, 2019). For example, how does trace data inform the work practices and their effectivity? Can humans be reduced to data-generating robots (Gal et al., 2020; Rahwan et al., 2019)? Such a discourse is critical for engaging with people and workplace analytics in a rigorous manner.

Conversely, the practitioners' literature is concerned with the adoption of people and workplace analytics and its drivers in organisations, as well as practical guidelines on how to establish people and workplace analytics programmes. For example, such guidelines take into account stakeholders, organisational culture, required skills, and change management (e.g. Chakrabarti et al., 2017; Guenole et al., 2015; Levenson & Pillans, 2017; Visier, 2018).

4 Categorizing Conceptions and Underlying Theory

Not everything is new about people and workplace analytics. Scientific management includes the quantification of human labour and uses statistical means to inform managerial decision-making, and the information systems discipline has extensively researched management information and decision support systems (Laudon & Laudon, 2014). We argue that research on people and workplace analytics should be informed by a synthesis of existing theories in management and information systems literature as well as adjacent disciplines. Investigating the phenomenon, the existing theories and literature shall inform perennial aspects and issues of people and workplace analytics, as well as provide guidance for future research. Reviewing and categorizing literature is fundamental in academia and helps in understanding and analysing complex topics and domains (Nickerson et al., 2013). Unpacking the prevalent conceptions, i.e. the underlying and implicit assumptions authors have in

mind when discussing people and workplace analytics (Laurence & Margolis, 1999), organizes the extant knowledge and provides an overview of the field (Nickerson et al., 2013). To support such a review and categorization, we propose a categorization schema that is deduced from the three outlined challenges above. The schema is loosely inspired by Marler & Boudreau (2017) but extended and tailored to people and workplace analytics in the information systems and management community. We divide the schema into (1) "categories for conceptions", which addresses the ambiguity challenge, and into (2) "categories for underlying theory", addressing the sparse research and the lack of theoretical foundation. A preliminary test and coding of the literature showed a moderate variance per category, indicating the robustness, comprehensiveness, and explanatory power of the categories in both the practitioners and academic literature (cf. Nickerson et al., 2013). A synopsis of the schema, including examples, is available in the appendix. In the following, the category titles are highlighted in bold.

4.1 Categories for Conceptions

The **conception** specifies the underlying assumptions or thoughts, the mental representation, that the proponents of people and workplace analytics have in their mind when talking about the phenomenon (Laurence & Margolis, 1999). It typically includes "*a set of necessary and sufficient conditions*" and is crucial for organizing and categorizing knowledge (Laurence & Margolis, 1999, p. 10). Beyond the overall conception, it is helpful to break the conceptions down into their smaller constituents to address the ambiguity, as complex mental representations are formed through linking simple assumptions (Laurence & Margolis, 1999).

For examining the constituents of the conceptions, we base the categories on the dimensions of decision-making problems in the information systems discipline (Ives et al., 1980; Laudon & Laudon, 2014), because people and workplace analytics concerns decision-making. The dimensions include the primary **stakeholders**, the people responsible for driving people and workplace analytics in their organization; and the **expected outcomes** or targeted processes of people and workplace analytics. Further categories are the **methods** for performing people and workplace analytics; including the use of **information technology**; and the **type of data** being analysed (Ives et al., 1980; Laudon & Laudon, 2014).

4.2 Categories for Underlying Theory

Implied validity claims and propositions must be tested rigorously through **theoretical warrants** and evidence (Ngwenyama, 2019). The warrant is the theoretical construct (principle or rationale) through which evidence is interpreted, and depicts why and how evidence supports a particular claim (cf. Toulmin et al., 1984). In their study, Marler and Boudreau (2017), find that the majority of publications does not provide a theoretical underpinning on why and how people and workplace analytics works and produces valid and reliable outcomes. Beyond the theoretical constructs, the measurement constructs require equivalent scrutiny. How do the implemented measurements (operationalization) link to the theoretical constructs? Are the constructs coherent, valid, and reliable (Howison et al., 2010)? Quantitative data requires careful interpretation. Instead of merely counting user actions, meaning needs to be carefully ascribed and understood in the context of work (Hüllmann, 2019; Hüllmann & Krebber, 2020). Wider implications need to be considered when interpreting the data as well: people and workplace analytics adds transparency to work. Individuals understanding this transparency can engage in impression management, further skewing the reliability of insights from people and workplace analytics (Pachidi et al., 2016). Looking at artificial intelligence applications, promises of objectivity and fairness are discussed controversially. Data and decisions are not necessarily fast and unbiased (Ebrahimi et al., 2016). Data and decisions are not necessarily objective and effective (Zarsky, 2016). It depends on the humans designing the systems, the training data, and the implementation (Cowgill & Tucker, 2017).

We add the **level of analysis** as a category, because the confusion of levels between data and theoretical construct can render insights invalid (Markus & Robey, 1988). Markus and Robey (1988) distinguish individual, organization, and society levels. We add the group-level as a separate entity, as teams are a fundamental unit of the organization and a typical subject for people and workplace analytics (Hüllmann & Kroll, 2018; Levenson, 2018).

In the last category we subsume **side effects, unintended outcomes**, and relating people and workplace analytics to **existing research**, where such effects and outcomes are discussed. Do the proponents relate people and workplace analytics to management information systems or organization theory? People and workplace

analytics sees the application of predictive models for the forecasting of people-related outcomes. The goal is to help managers make good decisions (Levenson, 2018). Are the changing roles of the decisions and decision-maker addressed from an information systems perspective (Berente et al., 2019)? Is people and workplace analytics another step in the development of management information systems and decision support systems? Auxiliary questions that may be addressed include the balance of management control versus empowerment of the individual. Advancing from Taylorism organization theory progressed towards seeing organizations as complex socio-technical systems (Tursunbayeva et al., 2018). How does people and workplace analytics relate to this discourse? Is it a step back towards the mechanized human (Gal et al., 2017, 2020)? The increase of transparency and information spawns concerns of privacy and workplace surveillance (Ball, 2010), as well as resistance from employees (Zarsky, 2016). Are these concerns discussed from a legislative and ethical perspective (Agarwal et al., 2018)?

5 Conclusion

People and workplace analytics is a trend emerging in practice, with a growing market that offers solutions, services, conferences and manifests itself in reports and case studies. Despite the hype, the extent of academic inquiry is lacking. Striving for a shared and theoretically sound understanding of the phenomenon, we provide a categorization schema derived from the outlined challenges of people and workplace analytics. The schema can be filled out by collecting data through interviews, surveys, or literature reviews. Since practitioners and consultancies are exposed to a variety of conceptions of people and workplace analytics, and provide a majority of the extant literature, it is worthwhile for academics to learn from them (Stockhinger & Teubner, 2018). Future research using our categorization schema will help to identify the prevalent conceptions of people and workplace analytics and clarify the elicited gaps in knowledge. Moving beyond existing reviews, the application of our schema can unravel the hidden assumptions underlying people and workplace analytics towards unifying a scattered field.

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Appendix – Categorization Schema

Categories for Conception

Term
What term is being used?
Examples: People Analytics, Workforce Analytics, Human Resources Analytics.

Conception (Overall)
What are the implicit assumptions for understanding of people and workplace analytics?
Examples: Understood as a process/approach, or a software tool.

Information technology / Data sources
Does the conception consider information technology important to reach the goals? What data sources are collected and analysed?
Examples: IT as an enabler; Dashboards for visualization / Big data; Surveys

Methods
What are the methods being used?
Examples: Multivariate statistics; Qualitative analysis.

Stakeholders
Who is responsible and drives the topic?
Examples: Human resources; General management.

Outcomes
What is the main outcome, goal, or purpose?
Examples: Improve human resources processes (e.g. retention, hiring, talent development); improve people-related organisational outcomes more generally.

Categories for Underlying Theory

Underlying theoretical warrants / theoretical framework / epistemology
What underlying warrant, i.e. the logic, epistemological view, or theory, is implied when talking about people and workplace analytics and its outcomes?
Examples: How well can people data capture humans and lead to meaningful insights? What theory is used for interpretation of measurements?

Level of analysis
Which level of analysis is depicted?
Examples: Individual, group, or organisational level.

Side effects / Unintended Outcomes / Existing Research
What areas with an influence of or on the topic are addressed?
Examples: Ethics, privacy, surveillance, taylorism, laws, regulations, resistance, adoption, behavioural change, impression management, management information systems.

Appendix – Literature Review

We conduct a literature review across academic and practitioners' literature, because scientific research is scarce, while practitioners' and consultancies are driving the topic of people and workplace analytics. To identify relevant literature, we first search the academic databases SCOPUS and Web of Science. Second, we perform backwards and forward search, including references to practitioners' literature. Beyond the literature from the search, we included references that were brought to our attention on social media, or at conferences.

Keywords:

- People Analytics
- HR/Human Resources Analytics
- Workplace Analytics
- Workforce Analytics
- Social Analytics

Search Criteria:

- Title
- Abstract
- Keywords

SUSTAINABLE PHYSICAL ACTIVITY PROGRAMS FOR YOUNG ELDERLY – A FUZZY ANALYTIC HIERARCHY PROCESS APPROACH

CHRISTER CARLSSON[1], PIRKKO WALDEN[1], TUOMAS KARI[1,2], MARKUS MAKKONEN[1,2], & LAURI FRANK[2]

[1] Institute for Advanced Management Systems Research, Turku, Finland, e-mail: chris-ter.carlsson@abo.fi, pirkko.walden@abo.fi, tuomas.t.kari@jyu.fi, markus.v.makkonen@jyu.fi
[2] University of Jyvaskyla, Jyvaskyla, Finland, e-mail: tuomas.t.kari@jyu.fi, markus.v.makkonen@jyu.fi, lauri.frank@jyu.fi

Abstract Physical activity (PA) programs are useful to help young elderly stay in good shape for their senior years. These programs should be sustainable, as this would keep the users active for months and years. A PA program should build on activities that users find meaningful and/or best suited for their history of sports and exercise as well as their present physical capacity. The challenge is to make the best selection from a (long) list of possible activities. We worked out a method to help young elderly to build a sustainable PA program from a set of activities that experts have identified as contributing to health and fitness among young elderly. The method builds on the Analytical Hierarchy Process (AHP), an intuitive and much used approach.

Keywords: analytic hierarchy process, fuzzy numbers, fuzzy AHP, sustainable physical activity programs, young elderly.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.29
ISBN 978-961-286-362-3

1 Introduction

Physical activity (PA) programs (understood as weekly sets of exercises) are a much-promoted modern trend – "help you reach your goals faster" (polar.com) or "motivates you to reach your health and fitness goals" (fitbit.com) – and they appear in advertising for smart watches, activity bracelets, smart phone apps, and similar, but actual use seems to lag behind the visions. The ATH 2010-2017 study in Finland (Finnish Institute for Health and Welfare (THL), 2019) shows that in the age group 30-54 years, only 30% spent several hours per week in PA programs; in the 55-74 age group, the rate goes down to 15%, and in the 75+ age group, it is only 7%. Wallén et al. (2014) studied physical exercise among 2,500 elderly Swedes (the age group 65-84). In the sample, 12% of the female and 14% of the male showed no PA; 69% of the female and 64% of the male reported regular PA only at low or medium intensity (e.g., walking a dog), which does not give sufficient health effects. The remaining 20% showed regular PA at moderate or high intensity. Moreover, the young elderly themselves found (Wallén et al. 2014) that at 60, their bodies start to impose functional limitations on them. Sports and health care professionals recommend (THL, 2019) a minimum of 150 minutes of moderate intensity PA per week for health effects. Physical activities distributed over three sessions/week allow for recovery and give better effects than a single PA session. Higher intensity and/or longer duration give more effect than lower intensity and/or shorter duration, which should be easy to understand, adopt, and follow. Nevertheless, PA among the elderly age group appears to be far too low.

Our target group is the young elderly (60-75 age group). The young elderly group is included in the ATH 2010-2017 study, and the statistics show that only 15% spend several hours/week in PA programs. When asked, 77% of people in the 55-75 age group would like to be physically more active (THL, 2019), but there is likely to be no pay-off in over-doing it if there is limited PA history, i.e., people who have not done much exercise. A PA program should build on activities that users find meaningful and/or best suited for them and their present physical capacity. The programs should be sustainable, as this would increase the chances that the users stay active for months and years.

Physical wellness comes from physical exercise to build stamina, muscle strength, and balance, and to ward off age-related serious illness; sustained physical exercise helps to meet everyday requirements of life. We have found out, in our field work, that typical forms of exercise among young elderly include walking, running, Nordic walking, gym training, group training, cross country skiing, boule, dancing, and water sports. Studies (Bangsbo et al. 2019, Jonasson, 2017, Wallén et al. 2014) show that systematic PA contributes to good quality of life in senior years.

The understanding of why physical exercise matters comes from the young elderly themselves (Carlsson et al. 2018): "it is nicer to get old if you are in good shape" or a more sober version: "to get good remaining years". These insights also capture the motivation to get in better physical shape. Given the motivation, the focus then turns to what PA and exercises to select and how to get health effects from them. The 2011 Compendium of Physical Activity (CPA) (Ainsworth et al. 2011) offers a standard for designing weekly programs. The CPA quantifies the energy cost of 821 specific physical activities in terms of the metabolic equivalent (MET). MET is "the ratio of the rate at which a person expends energy, relative to the mass of that person, while performing some specific physical activity compared to the reference, which is set by convention at 3.5 ml of oxygen per kilogram per minute (the energy expended when sitting quietly)" (Ainsworth et al. 2011).

There are other studies on PA (e.g., Hukkanen et al. 2018) that build on the use of multi-sensor systems. Then again, there is a debate about what measurements are accurate enough to show the actual intensity and effects of different physical activities (Bangsbo et al. 2019). There appears to be more focus on getting precise measurements of PA (Hukkanen et al. 2018) than on the more important goal of finding ways to get (in our case) young elderly to decide on, adopt, and use PA programs, adapt them to their own needs and goals, and then to continue using them for months and years. Thus, we do not go into details with the precision of measurements but draw from the MET (CPA) and work out PA programs with METs. METs show the energy cost (effort) of a PA relative to sitting idle (Ainsworth et al. 2011). METs are objective measures and allow for goal setting (e.g., MET-minutes per week) and systematic registration and follow-up of activities.

We run a research program for large groups of young elderly with the goal to design PA programs, find ways to implement them with digital services, and get the digital service technology accepted, as well as studying how digital services will contribute to the forming of systematic PA routines among young elderly. The young elderly participants – at present more than 660 – have two key questions (Carlsson et al. 2017, 2019): "(i) what exercises are good and useful for me; and (ii) how can I get health effects from these exercises". The CPA (Ainsworth et al. 2011), which builds on numerous studies, offers partial answers to (ii) combined with the recommendation of "a minimum of 150 minutes per week of moderate intensity PA (programs)". To help young elderly users to get answers to (i), we work out a method to support the building of sustainable PA programs. The first version that we report here uses the Analytic Hierarchy Process (AHP) to select a PA program from a set of 35 activities that are popular among young elderly.

The underlying research problem has a wider scope. We want to find out if it makes sense to tackle the composition of sustainable PA programs as a multiple criteria decision problem, for which there are much validated theory frameworks (Zeleny, 1982). Then, we will test an actual decision process with multiple criteria using AHP and find out if the choice makes sense in our research program.

The paper is structured as follows. After this introduction section, in section 2, we will work out the composition of PA programs; in section 3, we will introduce AHP and fuzzy AHP methods; in section 4, we will use the fuzzy AHP to find suitable and sustainable weekly PA programs; section 5 is a summary that offers some solutions to the research problem.

2 Physical Activity Programs

We have realized that a good way to make a PA program sustainable – to make sure that the participants will continue with the program for months (or even years) – would be to build on selections of activities (cf. Figure 1) that fit a young elderly participant, his/her PA history, and physical fitness. The CPA (Ainsworth et al. 2011) offers a basis for designing PA programs. The intensity of a PA follows three classes – light, brisk/moderate, or vigorous. The energy spent (in MET-minutes) in a PA program helps to define weekly PA goals. However, METs come from controlled experiments with adults 18-65 years old and are only partially relevant for

young elderly (Ainsworth et al. 2011). There will be imprecision and variation as the young elderly are in different physical shape. For instance, 150 minutes of brisk walking (MET 3.5) gives 525 MET-minutes per week. An active young elderly with a moderate PA history and of reasonable physical fitness should easily reach a weekly level of about 600 MET-minutes (subjective personal experience), that will give short- and long-term health effects. But PA programs need to be individual and will develop over time as young elderly get in better shape.

Figure 1: A selection of PA forms.

In our on-going research program, we initially used a list of 35 physical activities including their MET levels (16 of these are presented in Table 1); the CPA lists some standards (Ainsworth et al. 2011) – a brisk walk is at 5 km/h (or 10 000 steps, 3.5 MET) and 210 MET-minutes for one hour. The numbers are average standards and not precise individual measures; nevertheless, they help in finding the activity levels needed to get health effects and guide users to set their level.

Table 1: A selection (16 out of 35) of physical activities, including MET values.

Activity	CPA METs		
	Low	Moderate	High
Basketball	4,5	6,0	8,0
Soccer	4,9	7,0	10,0
Swimming	3,5	6,0	9,8
Aquajogging	2,5	4,5	6,8
Cross-country skiing	6,8	9,0	12,5
Jogging	6,0	7,0	8,0
Walking	2,8	3,5	4,3
Running	6,0	8,0	9,8
Nordic walking	3,4	4,8	6,8
Golf	3,5	4,8	5,3
Gym training	3,5	5,0	6,0
Orienteering	6,8	9,0	11,0
Cycling	6,8	8,0	10,0
Cycling indoors	4,8	7,0	8,8
Yard work	3,0	4,0	6,0
Other activity	4,1	5,6	7,5

Digital services (in the form of smartphone apps with links for storing PA data on a secure cloud service) are useful for introducing PA programs (Carlsson et al. 2017). It should be easy for the user to record activities, to find the MET-minutes and to find out the levels reached in relation to weekly goals. It is also helpful to get summaries that show PA improvements over weeks and months.

We carried out a survey among the first participants in the research program to find out the most popular forms of PA among them (165 participants; all could report several PA forms). The top seven were:

1. Walking (141/165)
2. Incidental exercise (123/165)
3. Yard work (122/165)
4. Cycling (105/165)
5. Nordic walking (85/165)
6. Cross country skiing (69/165)
7. Gym training (63/165)

The results are in line with common wisdom on what PA forms are popular among active young elderly (Bangsbo et al. 2019); there was also a long list of more exotic PA forms brought by some participants. So far it appears that the list of PA forms that we offer meets the demand fairly well.

The first version of the application we developed runs on smartphones and supports the logging and reporting of daily and weekly PA (cf. Figure 2).

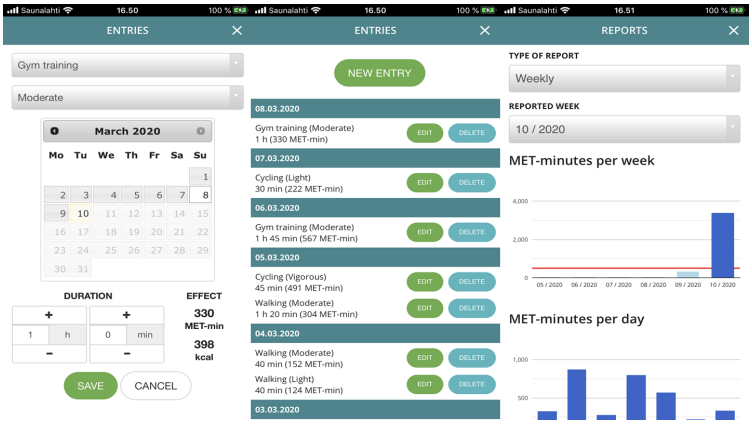

Figure 2: Posting and reporting of physical activities.

The data is stored into a database on a secure cloud server. The application collects user data in accordance with GDPR requirements, the users give their consent and appear only by pseudonym in the database. The first reactions to the program and to the digital support are positive, and we have observed that the young elderly have found the app supportive and effective.

3 Analytical Hierarchy Process and Fuzzy AHP Methods

A series of decision criteria guide the building of weekly PA programs and decide the selection of PA forms, intensity, and duration. The same type of criteria support evaluation of digital services (Yuan et al. 2015), and we will test how well they support the choice of weekly PA programs. We will use six, general form criteria (Yuan et al. 2015; actually, 5 of the 6 are UTAUT2 criteria (Venkatesh et al. 2016) that also potentially could be further specified for empirical studies:

– *Effort expectancy* – the physical effort invested in carrying out the weekly PA programs; the PA modules included have individually different effort expectancy

- *Performance expectancy* – the expected physical benefits (strength, endurance, speed, balance) the users expect from the weekly PA programs; PA modules have individually different performance expectancy
- *Social influence* – the degree to which individuals perceive support from friends, peers or PA groups for their weekly PA programs
- *Hedonic expectancy* – the expected degree of fun and pleasure derived from weekly PA programs
- *Psychological expectancy* – the expected effects of weekly PA programs in terms of sleep, stress and well-being
- *Added value* – expected payoff value relative to the time invested in weekly PA programs

Building weekly PA programs with guidance from six criteria is a multiple criteria decision problem (Zeleny, 1982). A special challenge is the fact that five of the six criteria are perceptions, not measurable facts; for added value there are good numerical methods available (Carlsson et al. 2015). A more detailed discussion of the perceptions shows that they are partly interdependent and partly conflicting (Carlsson & Fuller, 1997; 2000); effort and performance expectancy support each other (*added* effort gives *added* performance; *added* performance requires *added* effort; *added* effort gives *added* hedonic expectancy but *less* hedonic expectancy may give *added* performance). Perceptions rely on intuition and experience more than algorithms.

The AHP (Saaty & Vargas, 2002, Saaty, 2006) handles the comparison, evaluation and ranking of subjective multiple criteria by combining perceptions with systematic analysis. The AHP builds on pairwise comparison, first of the criteria, and then of the alternatives in relation to each one of the criteria; the comparisons are registered in a matrix and with matrix algebra (working out the eigenvalue) the ranking of alternatives relative to the criteria will be found (Saaty & Vargas, 2002). The classical AHP uses a precise numerical scale in the interval [1,9] to register preferences. This precision is intuitively problematic for pairwise comparison of perceptions (Vaidya & Kumar, 2006). If performance expectancy is 3 x more important to me than effort expectancy (when selecting a PA form), could it also be 2 x more important or 4 x more important? Is it at all possible to be precise on perceptions?

There is a better way to work with imprecision – the theory of fuzzy sets. There are two forms of fuzzy sets, type-1 and type-2 fuzzy sets. In type-1 fuzzy sets (Carlsson & Fuller, 2001), each element has a degree of membership in a set which is described with a membership function valued in the interval [0,1]; here 0 denotes "no membership" and 1 "full membership" – 0.8 denotes "more membership than no membership". A type-2 fuzzy set (Carlsson et al. 2015) is an extension of the type-1 fuzzy set as the membership grades themselves are type-1 fuzzy sets. They have proved useful for capturing linguistic uncertainties, e.g., words can mean different things to different people (Carlsson et al. 2015) (cf. expectancy on effort, performance, social influence, hedonic and psychological outcome; added value can be measured numerically). The membership functions of type-1 fuzzy sets are two-dimensional; the membership functions of type-2 fuzzy sets are three-dimensional and offer better tools to model uncertainties (Belohvalek et al. 2017).

Fuzzy AHP uses a linguistic scale, an interval type-2 fuzzy set, which offers more detail and flexibility than the classic AHP 9-point scale. Human judgment is normally not precise, and a 9-point scale forces cognitive compromises. The linguistic scale allows an evaluation and judgment of alternatives and criteria that allows for genuine imprecision. In real-world cases with multiple criteria (Carlsson & Fuller, 2000), decision makers simply do not know how alternatives contribute to criteria and have to offer their best guesses; if they are requested to select precise numbers from a 9-point scale offers their guesses are represented as precise estimates.

Fuzzy logic (Belohlavek et al. 2017) that builds on type-2 fuzzy sets offers a systematic, mathematically strong method to capture uncertainties in human cognitive processes. The Buckley fuzzy AHP method (Kubler et al. 2016) is one of the early contributions; it builds on the following steps (the mathematics is omitted, cf. Kubler et al. 2016; van Laarhoven & Pedrycz, 1983 for details):
The problem is formulated as a unidirectional hierarchy of criteria, (possible) sub-criteria and alternatives.

- A user compares decision elements (criteria, alternatives) pairwise in terms of importance for their upper-level criteria; the relative importance values are determined with fuzzy numbers (i.e., intervals), the numbers form fuzzy comparison matrixes on each level of the hierarchy.

- Fuzzy pairwise comparison matrices among all the criteria in the dimensions of the hierarchy system are constructed.
- The consistency of each fuzzy pairwise comparison matrix is checked; this requires that pairwise comparison values are "defuzzified" (i.e., intervals reduced to single numbers) using a graded mean integration method; this reduces much of the imprecision/uncertainty, but at this stage the comparisons have been made.
- To weigh criteria and alternatives we compute fuzzy geometric means for each row of matrices.
- Then we aggregate the fuzzy weights and fuzzy performance scores.
- The final step uses the classical AHP method to determine the best alternative.

4 Fuzzy Analytic Hierarchy Process

The experiment shown here is a young elderly individual who tries to build a weekly PA program that would be logically consistent with his idea of an effective (*effort*, *performance*) and enjoyable (*hedonic*, *social*, *psychological*) PA program. Experiments with groups of young elderly are next on the agenda (Saaty & Vargas, 2002, Vaidya & Kumar, 2006), added with features of individuals having different perceptions and preferences.

The AHP hierarchy in Figure 3 works out the most suitable weekly PA program for a young elderly participant. The goal to find the "most suitable weekly PA program (min 500 MET-minutes)" for young elderly builds on six criteria (cf. section 3). The *effort expectancy* is worked out for six forms of physical activities (Figure 3, first column); the six forms are then shown as {Physical activities} at the end of the other five criteria. The *performance expectancy* criterion is further worked out in terms of contributions to (ii.1) strength, (ii.2) endurance, (ii.3) balance and (ii.4) speed. The *social influence* comes from (iii.1) friends, (iii.2) peers, and (iii.3) PA groups (participating in the same physical activities). The *hedonic* and *psychological expectancy* are not further specified, and all six PA forms are evaluated on their contributions to fun + pleasure and less stress + better sleep + increased well-being, respectively (specified impact could be judged with better data). The *added value* is an estimate of the time used to reach the weekly goal (PA forms with higher MET values will require less time to reach weekly goals).

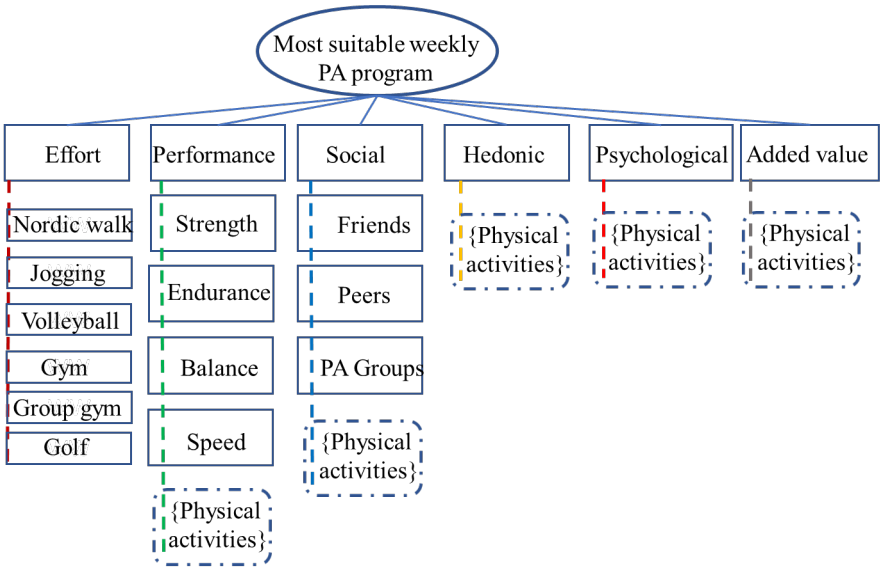

Figure 3: AHP hierarchy for deciding the most suitable PA program.

Studies have shown (Carlsson & Fuller, 1997; 2000) that multiple criteria evaluation offers cognitive challenges as soon as the number of criteria is more than 2-3 and the number of alternatives exceed 3-5 (Zeleny, 1982); here we have six criteria, two of which have 3-4 sub-criteria and six alternatives to be evaluated on the criteria and sub-criteria. Our goal is to find a weekly PA program of at least 500 MET-minutes that fits the preference structure we have decided among the criteria. The selection of physical activities include: (i) Nordic walking at moderate intensity (4.8 MET); (ii) jogging at moderate intensity (7.0 MET); (iii) volleyball in a group at vigorous intensity (6.0 MET); (iv) individual gym program at moderate intensity, 5.0 MET); (v) group gym program at moderate intensity (5.0 MET), and (vi) golf, 18 holes, walking and carrying bag (4.8 MET).

In the fuzzy AHP, the pairwise comparison and evaluation builds on a 5-point scale with intervals. Intervals are intuitively easier to deal with as four of the six criteria build on "expectancy". We have used the scale presented in Table 2 for "importance" and "preference" (e.g., *weakly more important* or *rather strongly preferred*). This is the simplest (triangular) form of fuzzy numbers; there exist other forms that capture specific types of imprecision and uncertainty (Belohlavek et al. 2018).

Table 2: Preferences as fuzzy numbers.

Code	Label	Lower	Mean	Upper
1	Equal	1	1	1
2	Weak	0.5	1	1.5
3	Rather Strong	1.5	2	2.5
4	Very strong	2.5	3	3.5
5	Absolute	3.5	4	4.5

Table 3: Ranking of primary criteria after a summary of pairwise comparisons.

Rank	Criterion	Weight
1	Performance	0.336
2	Added value	0.219
3	Effort	0.198
4	Social	0.125
5	Hedonic	0.122
6	Psychological	0.000

The evaluation used an online version of the fuzzy AHP method (www.online-output.com/fuzzy-ahp-software). Pairwise comparison which built on individual judgment over all criteria using the fuzzy 5-point scale gave the following results presented in Table 3: For example, we find that *performance* is perceived more important than *added value*, which in turn is perceived more important than *effort*.

Then we carried out pairwise comparison and evaluation of sub-criteria for the criteria "Performance" and "Social" using the same scale for "importance", which gave the following results (Table 4).

Table 4: Ranking of sub-criteria of Performance and Social.

Rank	**Sub-criteria**	**Weight**	**Sub-criteria**	**Weight**
1	Endurance	0.584	PA Groups	0.665
2	Strength	0.415	Friends	0.345
3	Speed	0.001	Peers	0.00
4	Balance	0.000		

Finally, pairwise comparison and evaluation of all the alternatives in relation to all the criteria (and sub-criteria where relevant), followed by a summation of eigenvalue vectors, gave the ranking of the alternatives relative to the goal ("most suitable weekly PA program of minimum 500 MET-minutes") presented in Table 5.

Table 5: Summary ranking of physical activities in relation to all criteria and sub-criteria.

Rank	Alternative	Weight
1	Nordic walking	0.312
2	Jogging	0.287
3	Volleyball	0.197
4	Gym (moderate)	0.115
5	Group gym	0.055
6	Golf	0.032

The ranking is intuitively acceptable as it is consistent with the ranking of the criteria: Alternatives 1 and 2 contribute to "Endurance" (ranked first sub-criterion on "Performance"), both give high expected value relative to the time invested and both require high physical effort in a weekly PA program. Alternative 3 contributes to "Performance", "Added value" and "Effort" but also more to "Social" than alternatives 1 and 2 as it requires a PA group (with rank 1 on "Social").

A weekly 2-hour 30 min program of Nordic walking at moderate intensity gives 720 MET-minutes. If we combine 1 hour 30 min of moderate Nordic walking with 1-hour vigorous volleyball, we get 792 MET-minutes. A combination of 1-hour moderate Nordic walking and a 1-hour moderate gym-program combined with 30 min of moderate group gym gives 738 MET-minutes. Thus, we can get a "most suitable weekly PA program" simply by selecting alternatives from the ranking. Updated lists can be run, for example, every week if we want to change preference profiles and get variations.

5 Summary and Conclusions

A meaningful composition of a PA program makes it more sustainable among young elderly users: Sustainable PA programs will more likely be part of everyday routines and continue to be routines for months and years to come. Sustained PA programs will also improve the probability for better health in senior years and contribute to better quality of life. This will also contribute to saving health care costs of ageing population as large groups of young elderly – and later seniors – stay healthier.

The research problem we wanted to tackle was to find out if it will make sense to compose sustainable PA programs with multiple criteria. As noted above, creating ready PA programs for young elderly is likely to positively contribute to their physical wellness and to improve quality of life. The study resulted in a solution for creating PA programs: yes, it makes sense to use a multiple criteria theory framework if there exist different preferences, a good selection of PA forms, different contributions of PA forms to preferences, and a stated goal to be attained. Although this solution is preliminary, we can conclude that the fuzzy AHP offers a useful theory framework for selecting PA forms.

As to the ranking, it can be concluded that the top list of activities is intuitive and similar to what we found in field work. Considering the criteria and sub-criteria, we found Nordic walking, jogging, volleyball, individual and group gym, and golf to be on the top of the ranking list. These activities can provide a suitable physical activity load for the young elderly.

The next step in future research will be to select groups of young elderly and build PA programs as group processes. This should show the variety of preferences for the criteria and whether some consensus on a best selection of PA programs can be found. Further research will aim to utilize the used fuzzy AHP method to create PA programs for other segments.

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SUSTAINED ADOPTION OF SYSTEMATIC PHYSICAL ACTIVITY FOR YOUNG ELDERLY – A DEVELOPED UTAUT APPROACH

CHRISTER CARLSSON[1], TUOMAS KARI[1,2], MARKUS MAKKONEN[1,2], PIRKKO WALDEN[1] & LAURI FRANK[2]

[1] Institute for Advanced Management Systems Research, Turku, Finland, e-mail: chris-ter.carlsson@abo.fi, tuomas.t.kari@jyu.fi, markus.v.makkonen@jyu.fi, pirkko.walden@abo.fi
[2]University of Jyvaskyla, Jyväskylä, Finland, e-mail: tuomas.t.kari@jyu.fi, markus.v.makkonen@jyu.fi, lauri.frank@jyu.fi

Abstract Health recommendations state that for young elderly systematic physical activi-ties at moderate intensity for at least 150 minutes per week are required to help them stay in good shape for their senior years. We have found that young el-derly readily gets started with a physical activity (PA) program but there is some challenge to make them stay with this program. We have learned that a PA program should build on activities that users find meaningful and/or best suit-ed for their history of PA and their present physical capacity. Support from dig-ital services to find meaningful and suitable programs can make a difference. We work out developments of the UTAUT to find drivers that could help build a sustained adoption of PA programs and propose a model for Systemat-ic Physical Activity Programs (SysPAP).

Keywords: physical activity programs, digital service support, UTAUT, young elderly, sustained adoption.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.30
ISBN 978-961-286-362-3

1 Introduction

Health care professionals have worked out (THL, 2019a) a recommendation that adults need a minimum of 2.5 hours of moderate physical activity (PA) per week to stay healthier. Higher intensity and/or longer duration give more effect than lower intensity and/or shorter duration. The activities should form a weekly program in order to become a routine or a habit that would be sustained for months and years. A sustainable PA program is key to get long-term health effects. Despite this, PA among Finnish adults is way too low. The ATH 2010-2017 study in Finland (THL, 2019a) shows that in the age group of 30-54 years, only 30% spent several hours per week in PA-programs and in the 55-74 age group, it decreases to 15%. In the 75+ age group only 7% are active for several hours. Moreover, a recent FinHealth2017 study (THL, 2019b) found that 39% of men and 34% of women in Finland reach the recommended levels of PA. The FinHealth2017 study forms a representative sample for the Finnish population. The material is extensive and subsets of it are presented in Tables 1-3.

Table 1: Physical activity, leisure time, proportion of age group (FinHealth2017).

Physical activity, leisure time						
	50-59	**60-69**	**70-79**	**80+**		
No physical activity (%)	28.5	25.4	29.7	48.6	**M**	**25.8**
	26.8	23.9	36.4	73.2	**F**	**29.5**
Light physical activity (%)	44.6	55.0	50.1	37.9	**M**	**40.1**
	50.3	56.2	47.6	22.8	**F**	**44.3**
Fitness physical activity (%)	25.9	19.3	20.0	13.5	**M**	**29.8**
	22.5	19.6	16.1	4.1	**F**	**25.8**
Active sports (%)	1.0	0.3	0.2	0.0	**M**	**4.3**
	0.3	0.3	0.0	0.0	**F**	**1.1**
Sitting (with smart devices (min/day))	172	216	222	206	**M**	**192**
	156	206	223	222	**F**	**174**

In Table 1, we have extracted age groups 50-59, 60-69, 70-79, and 80+ from the material. The table shows the proportion of participants at different PA levels for different age groups as well as the differences between male (**M**) and female (**F**) participants; the last column shows the weighted averages over all age groups (also including 18-29, 30-39, and 40-49). "Light PA" gives little long-term health effects, "fitness PA" is according to health recommendations, and "active sports" represent athletic and competitive activities. The last row shows minutes/day of sitting during

leisure time, which is a source for worries among health care professionals (THL, 2019b).

Our target group is the young elderly (60-75 age group), for which the recommendation is to spend a minimum of 150 minutes/week at moderate PA in order to stay healthier in senior years (Jonasson, 2017).

Table 2: Physical activity, leisure time, following health recommendations (FinHealth2017).

Physical activity, re health recommendations						
	50-59	**60-69**	**70-79**	**80+**		
No physical activity (%)	20.2	19.2	17.5	28.0	**M**	**16.5**
	12.2	11.9	23.8	38.9	**F**	**13.2**
Light physical activity (%)	16.0	21.6	27.4	40.8	**M**	**14.7**
	13.1	24.0	23.2	37.7	**F**	**15.5**
Some brisk, some vigorous (%)	16.0	14.6	14.3	7.3	**M**	**13.6**
	22.1	20.4	18.3	9.1	**F**	**19.8**
Endurance, recommendations (%)	17.4	15.8	12.0	10.6	**M**	**16.5**
	19.6	15.3	14.2	5.5	**F**	**17.4**
Endurance, strength, > 2 days (%)	30.3	28.8	28.8	13.3	**M**	**38.7**
	33.0	28.4	20.5	8.8	**F**	**34.1**

In Table 2, where the PA is registered in relation to health recommendations ("brisk" = "moderate"), the last two rows show PA that combines endurance activity with strength training and in which the activity is distributed over more than two days/week. In the 50-59 age group, 30.3% of the male and 33.0% of the female participants met the recommendations; for the 70-79 age group, this is down to 28.8% and 20.5%, respectively. The weighted average for all age groups is 38.7% (**M**) and 34.1% (**F**).

Physical wellness comes from physical exercise to build stamina, muscle strength, and balance, and to ward off age-related serious illness. Sustained physical exercise helps to meet everyday requirements of life. Studies (Jonasson, 2017; Wallén et al., 2014) show that systematic PA contributes to good quality of life in senior years. In our field work, we have found out that typical forms of exercise of young elderly include walking, running, Nordic walking, gym training, group training, skiing, bocce, dancing, and swimming. The FinHealth2017 study found that the most

popular forms of PA were the same; here we have extracted the PA forms most favoured among the young elderly (Table 3).

Table 3: Physical activity, leisure time, several times/week (FinHealth2017).

Physical activity, several times/week, summer						
	50-59	**60-69**	**70-79**	**80+**		
Yard, garden work (%)	18.8	30.1	35.6	25.7	**M**	**19.0**
	37.7	45.4	42.9	36.1	**F**	**31.4**
Walking, stairs (%)	64.5	56.6	53.0	54.4	**M**	**65.4**
	69.8	59.1	52.6	42.8	**F**	**67.0**
Walking, Nordic walk (%)	48.9	57.2	58.2	60.2	**M**	**53.9**
	69.0	71.9	63.0	52.9	**F**	**69.1**
Bicycling (%)	22.6	24.6	19.8	21.4	**M**	**27.6**
	42.4	33.6	31.9	18.2	**F**	**36.0**
Gym, strength training (%)	12.1	8.4	9.1	6.6	**M**	**19.3**
	8.6	7.5	2.6	1.8	**F**	**13.6**
Cross-country skiing, winter (%)	8.3	10.2	11.1	5.9	**M**	**8.6**
	6.1	7.2	3.6	1.9	**F**	**4.1**
Gym, strength training, winter (%)	15.3	9.9	12.6	2.6	**M**	**21.1**
	13.7	9.6	5.4	4.0	**F**	**16.5**

The most favoured forms of PA are walking, Nordic walking, and yard or garden work. Additionally, one of the most favoured activities is the choice to walk the stairs. Gym and strength training are much less favoured.

The FinHealth2017 study offers several insights for the young elderly age group: (i) the proportion that carries out PA according to health recommendations should be much higher; (ii) PA carried out several times per week should be of sufficient intensity and duration (at least 150 minutes/week at moderate or 75 minutes/week at vigorous intensity); (iii) time spent sitting should be reduced. The 2011 Compendium of Physical Activity (CPA) (Ainsworth et al., 2011) quantifies the energy cost of 821 specific activities in terms of the metabolic equivalent of task (MET). This offers support for dealing with (i) and (ii). METs show the energy cost (effort) of a PA relative to sitting (Ainsworth et al., 2011). It is an objective figure and can be useful for goal setting (e.g., MET-minutes/week) as well as for registration and follow-up of PAs.

In our ongoing research program, young elderly participate in groups to design PA-programs, find ways to implement them with digital services, and to get the digital service technology accepted. Currently there are more than 660 participants in the program. The underlying *research problems* have a wider scope:

- Will the PA programs, with the support from digital services, be adopted and used by the young elderly user group?
- What factors or drivers can help to sustain adoption of PA programs, so that they become a habit or a routine?
- Will these routines help young elderly to continue with PA programs for health effects also in their senior years?

In section 2, we present the composition of PA programs and digital services. In section 3, we introduce variations of the UTAUT (Venkatesh et al., 2012) framework. In section 4, we propose a new framework that will describe, explain, and guide the adoption of systematic PA programs. Finally, section 5 is a summary and offers some solutions to the research problem.

2 Physical Activity Programs and Digital Services

An efficient way to make the adoption of a PA program sustainable, that is, to make participants continue for months or even years, would be to build on selections of activities (cf. Figure 1). These should fit a young elderly participant, his/her PA history, and his/her physical fitness. The CPA (Ainsworth et al., 2011) offers a basis for designing PA programs. The intensity of a PA follows three classes – *light*, *moderate,* and *vigorous* – and is measured with METs (Ainsworth et al., 2011). The health recommendations (THL, 2019a; Bangsbo et al., 2019) correspond to roughly 500 MET-minutes per week, which will give short- and long-term health effects.

Digital services (in the form of smartphone apps with links for storing PA data on a secure cloud service) are useful for getting people started with PA programs (Carlsson and Walden, 2018) and should also work for building sustainable weekly PA programs. It should be easy to record activities, to find MET-minutes and if weekly goals have been met. Summaries show progression over weeks and months to verify that the PA programs contribute to improved PA.

In the research program, we initially used a list of 35 physical activities including their MET values (cf. Figure 1 for a subset).

Activity	CPA METs		
	Low	Moderate	High
Basketball	4,5	6,0	8,0
Soccer	4,9	7,0	10,0
Swimming	3,5	6,0	9,8
Aquajogging	2,5	4,5	6,8
Cross-country skiing	6,8	9,0	12,5
Jogging	6,0	7,0	8,0
Walking	2,8	3,5	4,3
Running	6,0	8,0	9,8
Nordic walking	3,4	4,8	6,8
Golf	3,5	4,8	5,3
Gym training	3,5	5,0	6,0
Orienteering	6,8	9,0	11,0
Cycling	6,8	8,0	10,0
Cycling indoors	4,8	7,0	8,8
Yard work	3,0	4,0	6,0
Other acticity	4,1	5,6	7,5

Figure 1: List (subset) of physical activities, including MET values.

The first set of developed digital services consisted of a smartphone app that supports the logging and reporting of PA (cf. Figure 2). To log a PA, a user selects the form and intensity of the activity, selects the date, and enters the duration; the app responds with the energy expenditure in MET-minutes and kcal. The app sends the data to a secure cloud server (operated by the Social Insurance Institution of Finland) where the participants appear only by pseudonym. The data is used to give weekly, monthly, and yearly reports to make it easy to monitor the progress relative to the user's personal goals.

Drivers for the adoption of digital services have been identified and studied (Yuan et al., 2015) in the context of wellness apps. The drivers for the intention to continue using the apps come from the UTAUT2 model (Venkatesh et al., 2012). They include (summarised from Yuan et al., 2015): (i) performance expectancy ("degree to which the use of a technology will help users to perform chosen activities"); (ii) effort expectancy ("degree of ease in the use of a technology"); (iii) social influence ("perception that important others support the use of technology"); (iv) facilitating

conditions ("factors that facilitate or impede adoption of technology"); (v) hedonic motivation ("fun or pleasure with using a technology"); (vi) price value ("trade-off between perceived benefits of and monetary cost for using a technology"); (vii) habit ("perception of automatically engaging in a certain behaviour").

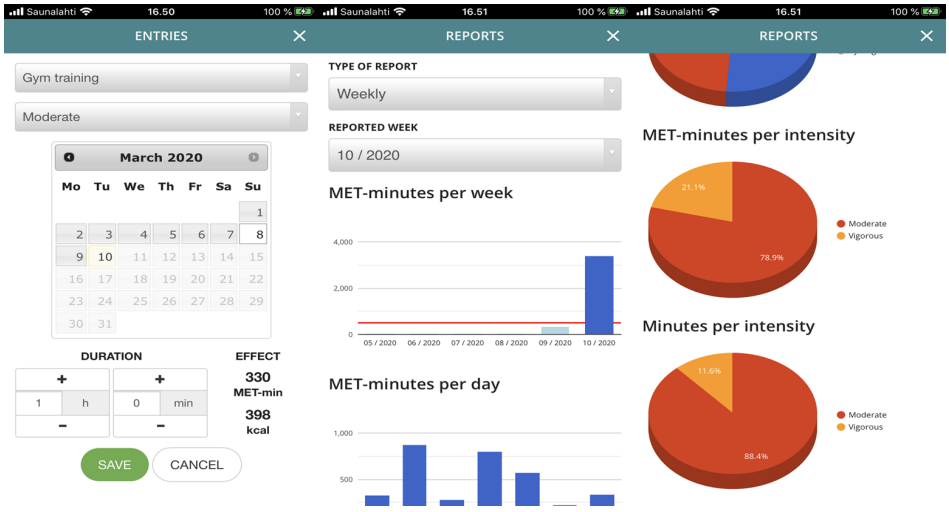

Figure 2: Logging and reporting of activities.

The UTAUT2 addresses the acceptance and use of information technology. *Digital services* are information technology by common understanding – they are delivered via the internet or an electronic network, they are automated, and they typically require little or no human intervention.

3 UTAUT and Its Variations

In (Reyes-Mercado, 2018), it was found that performance expectancy and effort expectancy have high net effects on the use and intention to use for adopters of fitness wearables. The study by Alshare-Mousa (2014) works out the intention to use mobile payment devices and adds a few interesting constructs. It finds that performance expectancy, social influence, and perceived information security are significant drivers of a consumer's behavioural intention. It also found uncertainty avoidance, masculinity, and collectivism to have moderating effects. A study of how students use social networking sites (Borrero et al., 2014) confirms that effort expectancy, social influence, and performance expectancy are key drivers.

Technology readiness (TR) had a moderating effect on the drivers, especially on effort expectancy among female students and students with self-reported low-level TR. Male students and students with self-reported high-level TR showed moderating effect on social influence. Knowledge management systems have specific benefits and challenges. When studied with the UTAUT framework, Bourdon-Sandrine (2009) found performance expectancy and social influence to act as drivers of the intention to use. The found facilitating conditions were novel: organizing structure, available time, time allocated, and incentives.

An integration of theories from collaboration research (i.e., social presence theory, channel expansion theory, and the task closure model) with UTAUT offers an interesting basis for work with collaboration technology (Brown et al., 2010). This proposes that collaboration technology features, individual and group characteristics, task characteristics, and situational characteristics are predictors of performance expectancy, effort expectancy, social influence, and facilitating conditions. The intention to use collaboration technology is moderated by gender, age, and experience.

Chiu-Wang (2008) expanded UTAUT for a study of user loyalty or subsequent continued usage. The added construct was subjective task value, and the results showed that performance expectancy, effort expectancy, computer self-efficacy, attainment value, utility value, and intrinsic value were significant predictors of intentions to continued use, whereas anxiety had a significant negative effect. UTAUT was used as the framework for a study of system use in Facebook, which is a hedonic volitional setting (Lallmahomed et al., 2013). A novel result was that hedonic performance expectancy is significantly related to cognitive absorption. Another result was that the user/task aspects better explain Facebook use than the system/task aspects, i.e., what the user wants to achieve is a stronger driver than the technical capabilities of the system. The study by Neufeld et al. (2007) represents a classical UTAUT setting – a large-scale IT implementation in an organisation. The novel factor is project champion charisma, which was found to be positively associated with increased performance expectancy, effort expectancy, social influence, and facilitating condition perceptions of users.

Conventional technology acceptance models do not offer any good understanding of behaviour related to internet services (Oh-Yoon, 2014). The authors found that modifying the UTAUT by adding the concepts "trust" and "flow experience" they could find better explanations for behavioural intention towards internet services (e-learning and online gaming). An early modification of the UTAUT framework offers some modified constructs (Venkatesh et al., 2008). Behavioural expectation replaces behavioural intention and facilitating conditions. System use is classified in terms of duration, frequency, and intensity. Age, gender, and experience moderate the impacts of facilitating conditions on behavioural expectation: experience moderates the impacts of behavioural intention and behavioural expectation on use. The first systematic extension and adoption of UTAUT to consumers (Venkatesh et al., 2012) added three constructs: hedonic motivation, price value, and habit. Individual differences in terms of age, gender, and experience moderate the effects of the new constructs on behavioural intention and technology use.

In 2016, Venkatesh et al. worked out a broad synthesis of the UTAUT constructs and numerous modifications and extensions of the original UTAUT framework (cf. Figure 3).

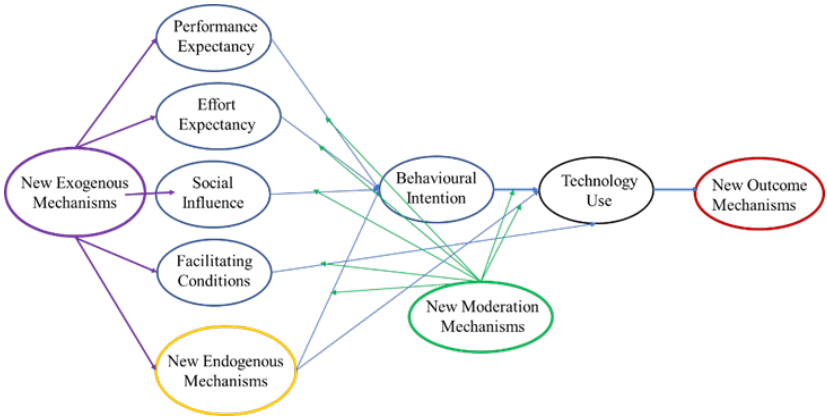

Figure 3: Types of UTAUT extensions (Venkatesh et al., 2016).

The focus was on technology users, not general organisational members. Technology attributes include the overall function and features like usability. Task attributes include task type and stages of the sequence of tasks. The relevant time is defined relative to the implementation of a target technology. The social context of

technology acceptance and use needs to be assessed. The location, physical environment, and conditions need to be specified for where the target technology is introduced, implemented, adopted, and used. Within this broad framework, it is now possible to work out variations of the UTAUT constructs that fit the context, the user groups, and the purpose for which we need to identify drivers for the adoption, adaptation, and use of information technology. The constructs offered by Venkatesh et al. (2016) give many degrees of freedom (cf. Figure 3): "technology use" is a driver of "new outcome mechanisms", which offers interesting opportunities, and there are new "endogenous", "exogenous", and "moderation" mechanisms for which there are candidates in the above overview.

In the next section, we will use the opportunity to propose and try out a few new constructs for digital service support of the implementation, adoption, and use of PA programs for young elderly.

4 Sustained Adoption of PA Programs through Digital Service Support

The FinHealth2017 material shows that the PA levels among young elderly are way too low. Numerous studies (e.g., Wallen et al., 2014; Bangsbo et al., 2019) have repeatedly shown that for young elderly, systematic PA programs contribute to better health in senior years. There is a need for good theoretical frameworks to show and explain how PA programs will be adopted and how the adoption will be sustainable, i.e., the users will stay with the programs for extended periods of time that will give them positive long-term health effects. In the following, we build a storyline that describes how the generic UTAUT framework adapts to the requirements for sustained adoption of PA programs; the storyline is influenced by the elaboration-likelihood model (ELM) first introduced in 1986 by Petty and Cacioppo (cf. Bhattacherjee & Sanford, 2006).

We need a **theory framework** and **models** for describing, explaining, and predicting the acceptance, adoption, and use of systematic PA programs through digital services. The PA programs are systematic weekly programs in a context of young elderly. The theory framework builds (as UTAUT) on commonly used theory instruments (such as the theory of planned behaviour by Ajzen, 1991) but is adapted to the specific requirements of the young elderly context. The models build on

experience with the UTAUT2 framework but use new exogenous, endogenous, and moderation mechanisms found to be relevant for the young elderly context.

There are **endogenous motivations** for young elderly to decide on sustained adoption of systematic PA programs. An often-stated motive is "*to get more good years*", which is a self-evident and strong objective. There are facts, news, and media discussions about the effects of PA on health and the chance to avoid serious illness in senior years. Young elderly have short-term goals to continue with their everyday routines and longer-term goals for plans on activities that require good or better physical shape.

Exogenous motivations for young elderly include physicians' health recommendations on PA programs to deal with diagnosed medical conditions. Public policy decisions on reduction in elderly care and cutdowns in budget costs for the aged population are drivers for young elderly to "*stay in shape, as care may not be available if we need it".*

Social influence is an exogenous factor for systematic PA programs. The strongest influence typically comes from family and loved ones that want to contribute to the "more good years". Young elderly can have peer groups with members in good or better shape that offer inspiration and encouragement, social media peer groups formed around similar PA programs and with similar short- and long-term goals, associations with senior sports activities, including former team-mates and competitors, as well as pensioners' associations with organized PA programs.

Aims for wellness & quality of life are endogenous factors to decide on a sustained adoption of systematic PA programs. Of the individual quality of life features, some have direct and others indirect connections with PA: to be in good physical and mental shape represents wellness; short-term goals for the next few months, e.g., to recover from medical problems; longer-term goals to realize plans in years to come on physical or intellectual projects, travel, new hobbies, major accomplishments, new life styles, or similar.

Behavioural intention for young elderly to decide on sustained adoption of systematic PA programs. This is intention to (i) accept, (ii) adopt, (iii) use, and (iv) continue to use systematic PA programs on a weekly basis (our present approach).

Moderation mechanisms. Age sets physical limitations – intentions may be different in different age groups [60, 65, 70, 75, 75+]. **Physical limitations** presented by BMI – differences in BMI may show in intentions. **Subjective assessment of physical shape** – differences may show in intentions and subjective assessment may differ from objective reality. **History of PA** – PA during the previous 10 years are more important than the nostalgic memories of physical prowess in younger years. **Work history** of physically conditioning activities vs. limited or no PA. **Physically conditioning** leisure activities vs. leisure time with no PA.

Technology use for young elderly to decide on sustained adoption of systematic PA programs. **Digital services** build on ICT infrastructure, architectures for data, information, and knowledge fusion, and systems of applications. **Functionality** that fits the users and their context, derived from a selection of the UTAUT mechanisms, guides the users to digital services. **User interfaces** that can be adapted to and tailored for young elderly users and are self-adaptive to users' cognitive style over time. **Coaching** adapted to and tailored for young elderly users and self-adaptive to users' PA levels and objectives over time. **Gamification** initiates and supports motivation for young elderly to use the digital services and the PA programs. ***Digital coaching*** supports the selection and use of PA programs as well as goal setting and attainment and can be integrated with gamification (cf. Kari et al 2016; Kari & Rinne, 2018). **Feedback reporting** on the fulfilment of (weekly) PA intentions, attainment of PA objectives, and dynamic goal achievement.

Sustained use of PA programs for young elderly can turn into habitual routines ("*settled or regular sequence of actions*"). A selection of systematic (weekly) PA programs for individual users to get actual **MET-min per week**, classified as light, moderate or vigorous; regular vs. irregular; sustained vs. non-sustained. **Subjective assessments** of light, moderate or vigorous; regular vs. irregular; sustained vs. non-sustained in follow-up measurements. **First goal** to reach 500 MET-min per week; consecutive goals through individual goal setting for systematic weekly programs. Testing PA programs for **habitual routines** (habits/routines). Subjective assessments of **short- and long-term effects**. The above listed constructs are summarised as the Systematic Physical Activity Programs (SysPAP) model in Figure 4.

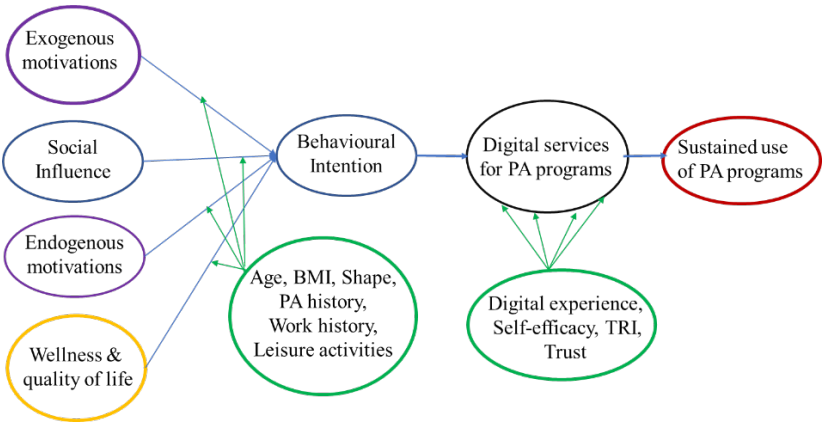

Figure 4: Sustained adoption of systematic PA programs – the SysPAP model.

5 Summary and Conclusions

In this paper, we present a model for Systematic Physical Activity Programs (**SysPAP**). The context of our model is the age segment called young elderly (60-75 years old). Health recommendations state that it is advisable for young elderly to be physically active in order to stay healthier during the senior years. This can be made practical with systematic, weekly PA programs (at moderate intensity for at least 150 minutes per week). The FinHealth2017 data shows that only about 28% of the young elderly reach this level and that significant action is required to get them to adopt routines that can contribute to healthier senior years. In our on-going research program, we aim to develop systematic PA programs and support them with digital services to make them accessible, easy to use, and motivational for young elderly. In our field studies (Carlsson and Walden, 2018, 2019) we have found that users get started with PA programs but do not stay with them. A PA program should build on activities that users find meaningful and best suited for their present physical capacity and PA history. Digital services can make a difference. The UTAUT framework is a good starting point for key constructs and drivers to reach sustained adoption of PA programs. We worked out a development of the UTAUT called SysPAP to find the drivers that could explain how young elderly adopt and stay with PA programs.

Obviously, the next step is to validate the SysPAP model empirically among the young elderly users. For this task, we have about 660 participants in our research program (at the moment). Both, cross-sectional and longitudinal studies are planned. The following step is to compare the SysPAP and the UTAUT2 frameworks for descriptive precision, for partial explanation, and for possible prediction.

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The Effects of Using a Mobile Wellness Application on Physical Activity Levels: A Four-Month Follow-Up Study Among Aged People

Tuomas Kari[1,2], Markus Makkonen[1,2], Lauri Frank[2], Joanna Carlsson[3] & Anna Sell[4]

[1] Institute for Advanced Management Systems Research, Turku, Finland, e-mail: tuomas.t.kari@jyu.fi, markus.makkonen@jyu.fi
[2] University of Jyvaskyla, Jyvaskyla, Finland, e-mail: tuomas.t.kari@jyu.fi, markus.makkonen@jyu.fi, lauri.frank@jyu.fi
[3] University of Turku, Faculty of Science and Engineering, Turku, Finland, e-mail: joanna.p.carlsson@utu.fi
[4] Åbo Akademi University, Faculty of Social Sciences, Turku, Finland, e-mail: anna.sell@abo.fi

Abstract Insufficient physical activity threatens people in older age. Thus, finding ways to support a physically active life in the older age is important. Digital wellness technologies have been presented as potential solutions, but in order for these solutions to be effective, research to gain insights on their use among aged people is needed. This study investigated how the use of a mobile wellness application for tracking physical activity affects physical activity levels among aged people. The physical activity levels were measured by using the IPAQ-E. The focus was on the first four months of use. The study was part of a research program in which groups of aged people take into use a mobile wellness application. The results show a modest, however, statistically not significant increase in the physical activity levels after the first four months of use. The study suggests that digital wellness technologies have potential for promoting physical activity levels among aged people.

Keywords: digital wellness, wellness technology, mobile, wellness application, mobile application.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.31
ISBN 978-961-286-362-3

1 Introduction

The ageing population is increasing: persons aged 65 years or older already represent around 18–22 % of the population in most EU countries, and the share is increasing in every EU member state (Eurostat, 2019). On a global scale, the number of people aged over 65 years is projected to double to 1.5 billion by the year 2050 (United Nations, 2019). At the same time, the life expectancy at older ages is improving: globally, a person aged 65 was expected to live additional 17 years in 2015–2020, which is expected to increase to additional 19 years by 2045–2050 (United Nations, 2019). This makes aged people an increasing priority area for policy makers and healthcare providers worldwide and raises an important question: how to support aged people to live a physically active life in older age?

This is a vital question as physical activity (PA) has significant health benefits across all age groups and contributes to the prevention of non-communicable diseases. Insufficient PA, on the other hand, is a global problem across all age groups and one of the leading risk factors for non-communicable diseases and death worldwide (WHO, 2018). The World Health Organization (WHO) provides research-based guidelines and recommendations for PA. These guidelines state, for example, that adults aged 65 years or older should do at least 150 minutes of moderate-intensity PA or at least 75 minutes of vigorous-intensity PA per week, or an equivalent combination of these. For additional health benefits, they should increase moderate-intensity PA to 300 minutes per week or equivalent. Additional PA to enhance balance and muscle-strength as well as to prevent falls should also be conducted (WHO, 2018). PA is imperative to ward off age-related illness and frailty (Hoogendijk et al., 2019). Moreover, several studies (e.g., Jonasson, 2017) show that systematic PA contributes to a better quality of life during older age.

Researchers in various fields have launched serious efforts to find solutions to support PA in different age groups. Digital wellness technologies, that is, *digital technologies that can be used to support different aspects of wellness*, have been presented as one potential solution. These include, for example, devices, applications, and services. For these to be effective, research is needed to gain insights on how they are used and what is the effect of their use specifically among aged people, as they form a user group with distinct needs and challenges. Research on the topic is also

important in order to optimize the development of digital wellness technologies for aged people so that the use would support PA.

The main purpose of this study was to investigate the following research question: Does using a mobile wellness application for four months affect the PA levels among aged people? The self-reported PA levels were measured before taking the application into use and after four months of use by using the International Physical Activity Questionnaire modified for the elderly (IPAQ-E) (Hurtig-Wennlöf et al., 2010). This study is part of a research program in which, among other things, groups of aged people take into use a mobile wellness application meant for tracking, following, and supporting their PA.

2 Digital Wellness Technologies

There are various digital wellness technologies, such as devices, applications, and services aimed for diverse target groups with different PA levels. The popularity of such technologies has increased greatly, and they are used by various types of users (Kettunen et al., 2017; Moilanen et al., 2014). However, these technologies are still mostly designed for younger populations, while a growing need among aged people is prevalent (Carlsson & Walden, 2017). Digital wellness technologies can support PA in various ways. For example, they can be used to increase PA levels – albeit with modest evidence (e.g., de Vries et al., 2016; Larsen et al., 2019; Romeo et al., 2019), and to reduce sedentary behaviors (e.g., Stephenson et al., 2017). They can support goal-setting (e.g., Gordon et al., 2019; Kirwan et al., 2013), provide instructions and digital coaching (e.g., Kari & Rinne, 2018; Kettunen & Kari, 2018; Sell et al., 2019), and provide social support (e.g., Sullivan & Lachman, 2017). They can also make PA more entertaining through exergames (e.g., Kari, 2014; Kari et al., 2020; Loos & Zonneweld, 2016) or gamification (Kari et al., 2016; Koivisto & Hamari, 2019). Digital wellness technologies can provide feedback in many forms, which can increase the users' awareness of personal PA and motivate towards it (e.g., Kang et al., 2009; Kari et al., 2017; Wang et al., 2016). However, an increased awareness of personal PA is not always enough for a continued use of the technology (Kari et al., 2017; Miyamoto et al., 2016), which, in turn, can disturb the maintenance of PA routines (Attig & Franke, 2020; Warraich, 2016). The potential of digital wellness technologies to promote PA among aged people has also been proposed, but

questions have been raised regarding their effectiveness, and more research is called for (e.g., Allmér, 2019; Larsen et al., 2019; Seifert et al., 2017.)

3 Methodology

3.1 The Application Used in the Study

The mobile wellness application used in the study is an application that is designed and developed in an ongoing research program run by the authors. It is an application within an application and operates inside the Wellmo application platform (Wellmo, 2019), which supports Android and iOS operating systems and in which the application features constitute their own entity. The application is aimed to support the forming of wellness routines in everyday life and is designed specifically for the aged people. The central features of the application are related to tracking PA. The application includes, for example, features for tracking and following one's conducted PA, weekly and monthly reports about the conducted PA, and the possibility to import data from external wellness services supported by the Wellmo application platform, such as Polar, Fitbit, Apple Health, and Google Fit. The application is under continuous development, and new versions are planned to be released twice a year with new features to support PA.

3.2 Research Setting, Data Collection, and Analysis

This study has a quantitative approach. The main purpose was to investigate the changes in PA levels before and after a four-month use period of a mobile wellness application. The study was based on the first field phase of the authors' ongoing research program mentioned in the previous section. In June 2019, the first wave of field groups with a total of 142 participants took the application into use. These groups acted as pilot groups before the next wave of field groups was launched in November 2019. Each group had one field researcher who, among other things, assisted in taking the application into use and educated the users on how to use the application. The study was conducted in Finland, and all the field groups were recruited via the Finnish pensioners' associations. During the first phase of the use which lasted four months (from June to October 2019), the participants used the application in their daily lives and conducted physical activities according to their own preferences. That is, they were not given any particular PA programs to follow

or specific goals to reach out for but could freely do what they wanted and when they wanted. The application and its use were free for the participants. However, the participants were required to have a smartphone of their own.

The focus of this study was on the first four months of use, meaning that the PA levels were measured before taking the application into use and after four months of use. The self-reported PA levels were measured by using the IPAQ-E (Hurtig-Wennlöf et al., 2010). The IPAQ-E is a modified version of the short-format IPAQ (Craig et al., 2003) validated with Swedish adults (Ekelund et al., 2006), and has been culturally adapted and validated for the elderly (Hurtig-Wennlöf et al., 2010). The IPAQ and IPAQ-E are specifically designed to provide a set of well-developed instruments that can be used internationally to obtain comparable estimates of PA (IPAQ group, 2005a). The IPAQ is the most widely used and validated PA questionnaire (Lee et al., 2011; van Poppel et al., 2010). The IPAQ-E focuses on collecting self-reported PA data concerning sitting time, walking, moderate PA, and vigorous PA from a period of the last seven days. For this study, the IPAQ-E questionnaire was translated from Swedish to Finnish with the help of the Finnish version of the short-format IPAQ questionnaire. Participants were Finnish and Swedish speaking (official languages in Finland), and thus, both language versions were used. The used questionnaires are available from the authors by request.

The data for this study were collected from the first wave of field groups. The first round of data collection took place in June 2019 and the second (follow-up) during November 2019. The data were collected with printed IPAQ-E questionnaires that were handed to the participants in field meetings organized with each field group separately. Before answering the questionnaire, the researchers responsible for the data collection gave oral and written instructions on filling and answering. No time limit was set for answering, and the participants could ask for clarifications if they felt the need. All participants gave a written informed consent. The local ethical committee was contacted before the start of the research program, and it was deemed that no separate approval was needed for this study.

The collected data were analyzed with the IBM SPSS Statistics 24 software. For the analysis, the *Guidelines for the data processing and analysis of the International Physical Activity Questionnaire* (IPAQ group, 2005b) and the guidelines presented by Hurtig-Wennlöf et al. (2010) were followed. Following the insights by Hurtig-Wennlöf et al. (2010, p. 1853), the PA data (continuous variable) are presented in *time in minutes spent in different intensities* instead of converting into metabolic equivalent of task values (MET) and MET-minutes (MET-min); and following the guidelines by the IPAQ group (2005b), the PA data are presented in *median minutes/week* rather than means; additionally, the interquartile ranges are presented. In addition to analyzing the PA levels, the participants were categorized into three PA categories (categorical variable: low, moderate, and high) based on the reported time of each activity in combination with a weighting factor for the different activities (i.e., a factor 3.3 for walking, 4.0 for moderate PA, and 8.0 for vigorous PA) (for details, see Hurtig-Wennlöf et al., 2010). Before the analysis, the standard methods for the cleaning and treatment of IPAQ datasets were conducted as advised in the *Guidelines for the data processing and analysis of the International Physical Activity Questionnaire* (IPAQ group, 2005b, p. 10-11). For example, in accordance with the truncation of data rules, if the reported times for walking, moderate, and vigorous activities exceeded 180 min/day, data were truncated to be equal to 180 min/day (IPAQ group, 2005b; Hurtig-Wennlöf et al., 2010).

The statistical significance of the changes over the four-month use period in the continuous variable were analyzed with the Wilcoxon (1945) signed-rank test because the focus was on medians rather than means. In turn, the statistical significance of the changes in the categorical variable were analyzed with the McNemar-Bowker test (Bowker, 1948). The level of statistical significance of both the tests was set to $p < 0.05$. The potentially missing values were handled by excluding the responses of a particular participant to a particular item if s/he had not responded to it in both data collection rounds. Thus, the exact number of respondents (N) may slightly vary between the items.

4 Results

In total, there were 142 participants in the first wave of field groups, out of which 99 responded to the IPAQ-E in both data collection rounds. Of them, 35.4 % were male and 64.6 % were female. The average age of the participants was 68.8 years (standard deviation 4.9 years). Descriptive statistics of those 99 participants are reported in Table 1.

Table 1: Descriptive statistics of the sample (N=99)

	n	%
Gender		
Male	35	35.4
Female	64	64.6
Other	0	0.0
Age		
Under 60 years	3	3.0
60–64 years	10	10.1
65–69 years	41	41.4
70–74 years	32	32.3
75 years or over	13	13.1
Language		
Finnish	65	65.7
Swedish	34	34.3

4.1 Analysis of the Continuous Variable (PA Levels)

Following Hurtig-Wennlöf et al. (2010, p. 1853) and the guidelines by the IPAQ group (2005b), the PA data are reported here in *median minutes/week spent in different intensities*, together with the interquartile ranges. These are reported for before and after the four-month use period along with the statistical significance of the changes from the Wilcoxon signed-rank test (Table 2).

Table 2: Changes in median minutes/week spent in different intensities (N=99)

		Before (min/week)		After (min/week)		p
Self-reported from the IPAQ-E	**n**	**Median**	**25th–75th percentile**	**Median**	**25th–75th percentile**	
Sitting	87	2100	1260–2520	2100	1680–2940	0.156
Walking	90	600	311–903	630	420–1050	0.076
Moderate activity	92	260	150–540	270	165–443	0.412
Vigorous activity	96	60	0–300	120	4–240	0.931

Regarding the changes in the *median minutes per week spent in different intensities*, there was a modest increase in walking, moderate activity, and vigorous activity. However, none of the changes were statistically significant. The median minutes per week for sitting remained unchanged.

4.2 Analysis of the Categorical Variable (PA Category)

The changes in the PA category were investigated by examining the changes in the number of participants in the PA categories Low, Moderate, and High (based on the IPAQ-E PA categorization) (Table 3). More precisely, it was investigated how many were increasingly active (i.e., moved from Low → Moderate/High or Moderate → High), decreasingly active (i.e., moved from High → Moderate/Low or Moderate → Low), or equally active (i.e., stayed in the same category) (Table 4).

Table 3: Changes in the number of participants in the different PA categories (N=99)

	Before		After	
PA category	**n**	**%**	**n**	**%**
Low	10	10.1	4	4.0
Moderate	23	23.2	23	23.2
High	66	66.7	72	72.7

Table 4: Changes in the PA categories after the four-month use period (N=99)

PA category	**After:** Low	**After:** Moderate	**After**: High
Before: Low	1	2	7
Before: Moderate	0	10	13
Before: High	3	11	52

Of the participants, 22.2 % were increasingly active, 14.1 % were decreasingly active, and 63.6 % were equally active after the four-month use period. The equally active participants could belong to any of the three PA categories. Interestingly, all but one of the ten participants who were initially in the Low category, increased their PA to Moderate or High. However, the McNemar-Bowker test suggested that the overall increase/decrease in PA was statistically not significant ($\chi 2(3) = 3.767$, $p = 0.288$).

5 Discussion

The main purpose of this study was to investigate the following research question: Does using a mobile wellness application for four months affect the PA levels among aged people? The study participants took into use a mobile wellness application that allowed them to track and follow their PA. The self-reported PA levels were measured before taking the application into use and after four months of use by using the IPAQ-E.

Regarding the PA levels, the changes in four types of PA (sitting, walking, moderate activity, and vigorous activity) were measured. In general, the results show a modest increase in the PA levels after the first four months of use. Whereas the median minutes per week spent in sitting remained unchanged, modest increases were observed in the median minutes per week spent in walking, moderate PA, and vigorous PA. However, although these changes suggested an improved PA level concerning these physical activities, they were statistically not significant at the $p < 0.05$ level. To summarize the answer to the research question, the four-month use period of a mobile wellness application had a slightly positive, although statistically not significant, effect on the PA levels of the participating aged people. In general, this is in line with the findings of Larsen et al (2019), who conducted a systematic review on the ability of physical activity monitors to enhance the amount of physical activity in older adults.

The participants were further categorized into three PA categories based on their overall PA level. These categories, as detailed by Hurtig-Wennlöf et al. (2010), were low, moderate, and high. The shifts of individual participants from one category to another were investigated. Overall, 22.2 % of the participants were increasingly active, 14.1 % were decreasingly active, and 63.6 % were equally active after the four-month use period. When examining this in detail, especially a shift from the low and moderate PA categories to the high PA category could be observed. However, a shift to the other direction was also observed as some people in the high PA category shifted to lower PA categories. A shift to a lower PA category may be explained by any incidents or other changes in the life of a participant. For example, if a highly active person faces an injury or other barriers to exercise, s/he is likely not able to conduct as much PA and, as a result, shifts towards lower PA categories. For people in the moderate PA category, such hindrances are logically not likely to have an equally great effect, and even less so for people in the low PA category. However, confirming the reasons behind shifting to a lower PA category would require detailed (qualitative) research on the individual cases in question.

It should also be noted that a relatively high number of the participants (66.7 %) belonged to the high(est) PA category (based on the IPAQ-E PA categorization) already before taking the application into use, and thus, they obviously could not shift to a higher PA category. Respectively, only 10.1 % of the participants belonged to the low(est) PA category before taking the application into use. This of course means that there were considerably more participants who could shift to a lower PA category compared to participants who could shift to a higher PA category. In spite of this, the participants rather shifted to a higher PA category than to a lower PA category after the four-month use period, although the overall changes in PA in terms of these shifts was found to be statistically not significant.

On average, the participants seemingly represented a physically more active share of the aged population (66.7 % in the high PA category). This is likely to downplay the possibility of the positive changes in the PA levels. For example, Kononova et al. (2019) who researched wearable activity tracker use among older adults found that the use gave the greatest benefits to former nonusers who were less active. Thus, it is plausible that the potential of mobile wellness applications in promoting PA levels among aged people is greater than the quantitative results of this study would suggest. To conclude, this study suggests that digital wellness technologies have

potential for promoting physical activity levels among aged people, but more research is needed.

6 Limitations & Future Research

Some limitations of the study should be acknowledged. First, the participants were not necessarily tracking their PA before taking the application into use, and thus, they might have had a less accurate view on their initial PA level. With the use of a tracking application, an individual is likely to become more aware of his/her PA level, and thus, the latter measurement of PA might be more accurate. Second, the timing of the study might have influenced the results. The initial PA level from the period of the last seven days was collected in summer, whereas the four-month period ended in autumn. Obviously, the time of the year may have manifold effects on the PA levels of an individual. Third, on average, the participants represented a physically more active share of the aged population, which limits the findings. Future research should pay special attention to recruiting participants from all PA categories. Fourth, the relatively short use period is likely to limit the results. Thus, future research calls for longer periods of use to investigate longer-term effects. Fifth, lack of a control group can be seen as a limitation, as we cannot explicitly be sure whether the measured changes were more due to using the application itself or due to being part of the study. Future research could also investigate the effects of using a mobile wellness application in different age groups or in different countries, or by focusing on other types of digital wellness technologies.

Acknowledgements

We would like to thank Prof. Christer Carlsson from the Institute for Advanced Management Systems Research for the insightful feedback.

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YOUNG ELDERLY AND DIGITAL COACHING: A QUANTITATIVE INTERVENTION STUDY ON EXERCISE SELF-EFFICACY

EEVA KETTUNEN[1], TUOMAS KARI[1,2], MARKUS MAKKONEN[1,2], LAURI FRANK[1] & WILL CRITCHLEY[1]

[1] University of Jyvaskyla, Jyvaskyla, Finland, e-mail: eeva.k.kettunen@jyu.fi, tuomas.t.kari@jyu.fi, markus.makkonen@jyu.fi, lauri.frank@jyu.fi, wcritchley@gmail.com
[2] Institute for Advanced Management Systems Research, Turku, Finland, e-mail: tuomas.t.kari@jyu.fi, markus.makkonen@jyu.fi

Abstract Sport and wellness technology devices are becoming an increasingly relevant topic when discussing health and wellness. This study focuses on the use of a "digital coach", within a specific population, young elderly people. This research explored how the use of a digital coach would affect self-efficacy related to physical activity and exercise among young elderly. This quantitative intervention study provided a digital coaching device to a group of young elderly people ranging from 61-78 in age for 10-weeks. It was found that a digital coach may be useful for this population, particularly in increasing their perceived confidence in exercising independently. However, the participants' perceptions of the device were more negative after the intervention period, although the overall perception was still positive. These results provide insight for sport technology companies and people who work with the young elderly on the possibilities of digital coaching and its usage for health promotion.

Keywords: digital wellness, physical activity, digital coach, self-efficacy, young elderly, sport and wellness technology, intervention.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.32
ISBN 978-961-286-362-3

1 Introduction

Use of Sport and wellness technologies has become increasingly popular. There is a wide variety of devices, applications, and services aimed for different target groups and for different needs. Indeed, they are used by various types of users and for various purposes (Kettunen et al., 2017; Moilanen et al., 2014). These technologies can potentially offer many benefits to their users. For example, they can be used to promote physical activity (PA) (e.g., de Vries et al., 2016; Romeo et al., 2019), to support goal-setting (e.g., Gordon et al., 2019), and to increase the awareness of personal PA (e.g., Kari et al., 2017a; Wang et al., 2016). However, these benefits may not maintain the use of sport and wellness technologies (Kari et al., 2017a; Miyamoto et al., 2016), which in turn can lead to reduction in PA levels (Attig & Franke, 2020). A common issue with sport and wellness technologies is that they mainly provide feedback through numbers or charts instead of instructional information. Providing personalized achievable goals, sufficient guidance, and easy to understand information might promote use adherence and help in maintaining PA and exercise routines. Further, feedback on how to promote exercise can make use of the devices more goal-oriented (e.g., Kari et al. 2017b), which can lead to increased motivation (Shilts et al., 2004). Hence, providing the users with actual guidance and personalized workout plans would increase the possibility of making both the use of the technology and the exercise routines more goal-oriented.

One potential solution for this is digital coaching, which refers to a "service on a technological device that not only gives feedback but also offers advice, suggestions and future steps for a user to follow in the pursuit of their wellness and fitness goals" (Kettunen & Kari, 2018, p.3). The potential of digital coaching regarding PA and exercise has been recognized. However, some limitations have also been raised (e.g., Kranz et al., 2013; Kari & Rinne, 2018; Kettunen & Kari, 2018; Kettunen et al., 2018; 2019a; Helmefalk et al., 2020). Thus, it is important to continue studying digital coaching solutions and their use. This study investigates the usage of digital coaches from an exercise psychology perspective. Specifically, the aim is to find out how the use of a sport and wellness technology digital coach affects exercise self-efficacy of the young elderly (i.e., age 60–75). The focus was on self-efficacy, due to its significant relationship with PA performance affecting the choice of activity, effort, persistence, and vulnerability to stress (Bandura, 1997). The main research question

of the study is: "Does the use of a digital coach affect self-efficacy related to PA and exercising within young elderly?"

Young elderly were chosen as the target group as it is imperative to find ways to help them lead a more physically active life before they become elderly. The share of elderly people is increasing: persons aged 65 years or older cover 18–22% of the population in most EU countries (Eurostat, 2019). In addition, the life expectancy at older ages is increasing globally (United Nations, 2019). PA has been shown to be a key component for a healthier life at older age (Hoogendijk et al., 2019) and finding ways to support it is essential.

2 Theoretical Background

This study's theoretical background is based on Bandura's (1977) theory of self-efficacy. Self-efficacy relates to a person's beliefs in their own capability to perform a specific task. If a person has high self-efficacy, they are likely to view difficult tasks as a challenge and an opportunity, while a person with low self-efficacy may tend to avoid difficult tasks. Self-efficacy may also affect motivation, as it impacts the amount of effort a person is willing to put in to overcome a specific task.

The sources of information that affect self-efficacy have been categorized into four aspects: performance accomplishment, vicarious experience, verbal persuasion, and physiological states (Bandura, 1998). Several of these aspects also closely relate to Bandura's social cognitive theory (1986) which suggested that a person's actions are influenced by their observations of the world around them and the actions of others. Social cognitive theory highlights how social experience and observational learning in development of personality is used as a framework when studying motivation and PA.

In this study, the theoretical background of self-efficacy could be said to take the form of "exercise self-efficacy", as the focus is primarily on PA and exercise. Self-efficacy has been shown to have high influence in adopting PA habits (McAuley & Blissmer, 2000), hence why it was chosen for this particular study. It has also shown to be even more important when PA has not become a habit (Bandura, 1986). Self-efficacy has been associated with maintaining long-term PA (McAuley et al., 2011), and hence people with high self-efficacy may participate in PA more frequently and work harder (Bandura, 1986). Self-efficacy is a widely used theory in studying self-

confidence and motivation in sport performance studies, and one of the most researched concepts in the fields of PA (Kroll et al., 2007) and sport performance (Feltz, 1988), which is a key reason for its focus in this study.

Another part of the theoretical framework, proxy agency theory, comes also from the work of Bandura. The proxy agency refers to a situation where a third-party acts as an agent on a person's behalf (Bandura, 1982; Beauchamp & Eys, 2007). There are three reasons for people to use a proxy agent. Firstly, people might feel they do not have the skills or knowledge to reach their desired outcome. Secondly, even though they would possess those skills they may think that having a proxy agent might lead to better results. Thirdly, using a proxy agent relates to the desire to hand over the responsibility and control to someone else (Bandura, 1997). In PA and exercise settings a proxy agent can refer, for example, to a coach or a personal trainer. In this particular study, the proxy agency theory is studied from the point of view of digital coaching, referring to a sport and wellness technology device consisting of digital coaching features. The interest is whether a digital proxy agent is also able to affect the feelings of competence and confidence by providing instructions, feedback, and persuasion as well as providing performance accomplishments similar to what a human proxy agent can.

3 Methodology

3.1 The Digital Coach Used in the Study

The device used in this study was the Suunto 3 Fitness (Suunto, 2019). The Suunto 3 Fitness is a fitness watch for monitoring daily PA, stress, recovery, and sleep, primarily through the device's wrist-based heart rate sensor. The watch can also be linked to a smartphone app which provides additional feedback and may also collect movement data by using the phone's GPS. One particular feature of the Suunto 3 Fitness is "adaptive training guidance" (i.e., a digital coach). The feature creates a customized training plan directly on the watch based on the user's background and training history. The training guidance provides several days of future workouts with specific details of the duration and intensity of each workout. If the user follows the recommended workout, it will also guide the user through the workout to ensure the session is performed at the correct intensity. This is done by monitoring the user's heart rate and providing real-time feedback through notifications on the screen, via the watch's vibration, or by audio. The guidance instructs the user to increase or

decrease the exercise intensity, most obviously by speeding up or slowing down. The training plan adapts after each workout based on the user's performance during that workout. If the workout is too hard or too easy, the plan may decrease or increase the intensity of future workouts. Criteria are built into the digital coach's algorithms to ensure that the training plan is also physiologically appropriate, such as by not planning two hard workouts in a row or by following well-known periodization methods when creating the training plan.

3.2 Data collection and analysis

The target population of this study was young elderly. The study was conducted as an intervention study and comprised an intervention group and a control group. The participants were recruited from a Finnish University of the 3rd Age (UTA), which offers weekly scientific sessions and a meeting spot for elderly people. The participants were recruited via a short presentation during a weekly UTA lecture, which resulted in recruitment of 80% of the participants. The rest were recruited via snowball method. All who volunteered for the study and were in the target age group were selected as participants. In total, 62 people volunteered for the study.

The participants were randomly divided into two sub-groups. The intervention group had 30 participants and the control group had 32 participants. The reason for limiting the number of participants in the intervention group to 30 was due to the number of available digital coach devices. Even though the division of participants into two groups was done randomly, the aim was to make the groups homogenous in terms of the number of men and women in each group. Participants' level of PA did not influence the sample selection nor the grouping. The 10-week-long intervention period started in June 2019. During the period, participants in the intervention group used the digital coach and participants in the control group continued their exercising without a digital coach. Participants in the intervention group were asked to use the device in the way that best suited them in order to make the user experience as convenient and pleasant as possible.

The data was collected via three online surveys. The first survey was sent to all the participants before the intervention group were given the digital coaches. The second survey was sent after 5 weeks and the third survey at the end of the 10-week intervention. The measurements were conducted identically for both groups in all three surveys: First, the questionnaire included an exercise self-efficacy scale by Kroll et al. (2007), consisting of 10 items on a four-point scale ranging from one (not at

all true) to four (exactly true). Second, there were 13 items concerning the self-efficacy of exercising and improving fitness in general as well as the role of sport and wellness technology in exercising. These statements were presented on a seven-point Likert scale ranging from one (strongly disagree) to seven (strongly agree). These items were not, as such, intended as measures of specific constructs related to self-efficacy, although some of the items shared common themes. Thus, the responses were examined at the item level instead of the construct level. Third, the questionnaire contained five items measuring the attitude towards using a digital coach as a support for training by using a seven-point semantic differential scale ranging from -3 to +3, which was rescaled for the analysis to range from 1 to 7. A lower score suggested a more negative attitude, whereas a higher score suggested a more positive attitude. In all parts of the questionnaire, the order of the items was randomized for each participant. Responding to the items was non-mandatory, meaning that missing values in the data were possible.

Participants' age ranged from 61 to 78 years. Information on the participants' PA background was collected using a categorization based on the Finnish National Sport Survey (Finnish Sports Federation, 2011), which classifies people into seven categories based on their PA level. The categories, in order from the most to least active, were: competition athletes, fitness athletes, fitness participants, physically active for health, active in commuting and non-exercise, occasionally active, and inactive or sedentary. This was enquired retrospectively after the study was finished. None of the intervention group participants had previous experience with a digital coach. However, 60% had at least tested a heart rate monitor or an activity bracelet before, 30% had used a PA application, and 20% had used a pedometer. 37% of the intervention participants had no previous experience with sport and wellness technology. Table 1 displays the descriptive statistics of the participants.

Table 1: Descriptive statistics of the participants and the two sub-groups.

	Whole sample (N = 62)		Intervention group (N = 30)		Control group (N = 32)	
	N	**%**	**N**	**%**	**N**	**%**
Gender						
Male	22	35.5	10	33.3	12	37.5
Female	40	64.5	20	66.7	20	62.5
Age						
61–65 years	17	27.4	7	23.3	10	31.3
66–70 years	26	41.9	15	50.0	11	34.4
71–75 years	16	25.8	7	23.3	9	28.1
76–80 years	3	4.8	1	3.3	2	6.3
Socioeconomic status						
Working	4	6.5	2	6.7	2	6.3
Retired	57	91.9	28	93.3	29	90.6
Other	1	1.6	0	0.0	1	3.1
PA background						
Fitness athletes	4	6.5	2	6.7	2	6.3
Fitness participants	22	35.5	11	36.7	11	34.4
Physically active for health	25	40.3	11	36.7	14	43.8
Active in commuting and non-exercise	9	14.5	4	13.3	5	15.6
Occasionally active	1	1.6	1	3.3	0	0.0
Sedentary	1	1.6	1	3.3	0	0.0

The data was analyzed using the IBM SPSS Statistics 24 software. The Wilcoxon (1945) signed-rank test was used because of the small sample size and the non-normal distributions of some of the items. A statistical significance threshold of $p < 0.05$ was used. If a participant did not answer a particular item in all three surveys, all responses from that participant of that particular item were excluded. Thus, the exact number of respondents (N) may vary slightly between the items.

4 Results

The results are reported in three sub-sections. The first sub-section concentrates on overall self-efficacy. The second sub-section focuses on self-efficacy specifically related to perceptions of sport and wellness technology as it pertains to training and improvement of PA. The third sub-section relates to attitude towards using a digital coach. From left to right, the columns of the tables report the number of respondents (N), the mean and standard deviations of the measures at the three time-points, and the p-values. The p-values are from the Wilcoxon signed-rank tests, and the first p-value is for the test comparing the statistical significance of the change in means between the first and second time-point, whereas the second p-value is for the test comparing the statistical significance of the change in means between the first and third time-point.

4.1 Exercise Self-efficacy

The scale used for measuring exercise self-efficacy (Kroll et al., 2007) included 10 statements regarding personal abilities related to PA (Table 2). The results show almost no statistically significant changes in exercise self-efficacy in either groups. The only time-point and statement where there was a statistically significant change was at the end of the intervention, where the intervention group felt more confident in their abilities to start exercising again after having stopped exercising for a while. The control group did not show any statistically significant changes.

Table 2: Changes in exercise self-efficacy (grey rows: intervention group, white rows: control group, scale: from 1 = "not at all true" to 4 = "exactly true").

Statement	N	Time 1		Time 2		Time 3		p (1 vs. 2)	p (1 vs. 3)
		Mean	SD	Mean	SD	Mean	SD		
I can overcome barriers and challenges with regard to PA and exercise if I try hard enough	28	3.4	0.6	3.3	0.7	3.3	0.6	0.593	0.157
	31	3.5	0.7	3.4	0.8	3.3	0.6	0.331	0.058
I can find means and ways to be physically active and exercise	28	3.4	0.6	3.4	0.7	3.6	0.6	1.000	0.059
	31	3.5	0.8	3.5	0.8	3.5	0.7	0.837	0.951
I can accomplish my PA and exercise goals that I set	28	3.0	0.7	3.1	0.7	3.2	0.8	0.439	0.132
	31	3.1	0.8	3.1	0.7	3.1	0.5	1.000	0.755
When I am confronted with a barrier to PA or exercise, I can find several solutions to overcome this barrier	26	3.0	0.8	3.2	0.7	3.3	0.7	0.096	0.117
	31	3.1	0.7	3.0	0.9	3.0	0.7	0.712	0.627
I can be physically active or exercise even when I am tired	26	2.6	0.8	2.6	0.9	2.8	0.8	0.675	0.160
	32	2.8	0.8	2.7	0.8	2.8	0.9	0.371	1.000
I can be physically active or exercise even when I am feeling depressed	21	3.1	0.7	3.1	0.5	3.1	0.7	1.000	0.782
	30	3.0	0.8	3.0	0.8	2.7	0.8	1.000	0.063
I can be physically active or exercise even without the support of my family or friends	28	3.5	0.6	3.6	0.7	3.6	0.6	0.454	0.480
	30	3.5	0.8	3.7	0.7	3.5	0.7	0.166	0.851
I can be physically active or exercise without the help of a therapist or trainer	26	3.5	0.8	3.7	0.5	3.7	0.5	0.161	0.197
	30	3.4	0.8	3.4	0.9	3.4	0.8	0.822	0.927
I can motivate myself to start being physically active or exercising again after I've stopped	27	3.2	0.7	3.4	0.6	3.6	0.5	0.052	**0.013**
	31	3.5	0.8	3.4	0.7	3.4	0.7	0.637	0.596
I can be physically active or exercise even if I had no access to a gym, exercise, or rehabilitation facility	28	3.6	0.7	3.6	0.6	3.5	0.6	1.000	0.763
	30	3.4	0.9	3.5	0.8	3.5	0.8	0.357	0.683

4.2 Self-efficacy Related to Exercising and Improving Fitness, and the Role of Sport and Wellness Technology

The self-efficacy related to the participants' overall opinions about their exercising and improving their own fitness was measured by a total of 13 statements, out of which six were related to the role of sport and wellness technology (Table 3).

Both the intervention and the control group were more confident at the end of the intervention that they do not necessarily need help in creating themselves a suitable training program. The intervention group also felt more confident to train without any kind of guidance or coaching at the end of the intervention. The intervention group also felt more and more strongly as the intervention went along that it was less hard for them to find out how to improve their fitness. The other statistically significant changes related to the intervention group losing some of their confidence on the truthfulness, accuracy, and reliability regarding the information given by sport and wellness technology. These changes appeared already at the midpoint of the intervention.

Table 3: Changes in self-efficacy related to improving fitness and sport and wellness technology (grey rows: intervention group, white rows: control group, scale: from 1 = "strongly disagree" to 7 = "strongly agree").

Statement	N	Time 1		Time 2		Time 3		p (1 vs. 2)	p (1 vs. 3)
		Mean	SD	Mean	SD	Mean	SD		
I know how to create myself an exercising program	29	4.0	1.8	4.4	1.6	4.5	1.6	0.082	0.093
	30	4.2	1.2	4.3	1.2	4.6	1.1	0.551	0.146
I know how to create myself an exercising program	29	4.0	1.8	4.4	1.6	4.5	1.6	0.082	0.093
	30	4.2	1.2	4.3	1.2	4.6	1.1	0.551	0.146
I need help in creating myself a suitable exercising program	30	4.8	1.5	3.8	1.8	3.4	1.8	**0.011**	**0.001**
	32	4.5	1.6	4.6	1.7	3.8	1.7	0.638	**0.004**
I am able to train independently without any guidance or coaching	30	5.1	1.5	5.2	1.5	5.8	1.3	0.440	**0.010**
	32	5.4	1.4	5.3	1.4	5.4	1.3	0.827	0.853
Sport and wellness technology has an important role in my exercising	27	3.6	1.8	3.8	1.5	3.7	1.4	0.487	0.683
	30	3.4	1.7	3.4	1.6	3.3	1.4	0.746	0.736

Sport and wellness technology provides me with important information that I can use in my exercising	30	5.7	1.2	5.0	1.4	5.1	1.2	0.052	0.051
	30	4.9	1.5	4.9	1.7	4.5	1.7	0.933	0.113
I am able to improve my fitness with the help of sport and wellness technology	30	5.3	1.4	4.7	1.6	4.8	1.7	0.076	0.116
	29	4.8	1.4	4.8	1.5	4.4	1.5	0.977	0.102
I believe that sport and wellness technology provides me with reliable information regarding my own exercising	30	5.9	1.0	5.0	1.4	4.7	1.3	**0.011**	**0.001**
	29	5.3	1.6	5.5	1.4	5.0	1.5	0.369	0.128
I believe that sport and wellness technology provides me with accurate information regarding my own exercising	29	5.4	1.2	4.8	1.2	4.7	1.5	**0.036**	**0.020**
	29	5.4	1.4	5.4	1.5	5.2	1.3	0.971	0.231
I believe that sport and wellness technology provides me with truthful information regarding my own exercising	30	5.6	1.0	4.9	1.3	4.8	1.5	**0.038**	0.054
	31	5.4	1.4	5.4	1.5	5.2	1.3	0.805	0.299
It is hard for me to find out how to improve my aerobic fitness	29	3.6	1.8	2.8	1.7	2.6	1.5	**0.036**	**0.019**
	30	3.5	1.9	3.3	1.7	3.3	1.7	0.838	0.569
I do not know how to increase the level of my aerobic fitness	30	2.8	1.6	2.3	1.5	2.4	1.7	0.147	0.186
	29	3.2	2.0	3.1	1.9	2.8	1.5	0.695	0.290
It is hard for me to analyze my aerobic fitness	30	4.1	1.6	4.0	1.5	3.5	1.7	0.681	0.053
	30	4.3	1.9	4.2	1.8	3.9	1.6	0.300	0.225
I know how to improve my aerobic fitness	30	5.3	1.4	5.2	1.3	5.7	0.9	0.697	0.071
	31	4.8	1.4	4.9	1.1	4.7	1.5	0.882	0.747

4.3 Attitude towards using a digital coach

The attitude towards using a digital coach was measured by five statements focusing on the following three aspects of attitudinal evaluations: the overall attitude (bad vs. good), the experimental aspect (unpleasant vs. pleasant and uncomfortable vs. comfortable), and the instrumental aspect (useless vs. useful and foolish vs. sensible) (Table 4). It is noticeable that both the intervention group and the control group

experienced a decline in their attitude towards digital coaching. For most of the statements, a statistically significant decline appeared already at the midpoint of the intervention. However, regarding comfortableness, a statistically significant decline appeared only at the end of the intervention. Despite the decline, the attitude of both the groups towards digital coaching still remained as relatively positive at the end of the intervention.

Table 4: Changes in attitude towards using a digital coach (grey rows: intervention group, white rows: control group, scale: from 1 to 7).

Statement	N	Time 1		Time 2		Time 3		p (1 vs. 2)	p (1 vs. 3)
		Mean	SD	Mean	SD	Mean	SD		
The thought of using a digital coach as a support for my training sounds: **bad (1) vs. good (7)**	30	5.8	1.3	5.5	1.1	5.3	1.3	0.090	0.082
	32	5.6	1.2	5.2	1.4	5.3	1.3	**0.042**	0.058
The thought of using a digital coach as a support for my training sounds: **useless (1) vs. useful (7)**	30	6.0	1.1	5.5	1.4	5.4	1.3	**0.006**	**0.003**
	32	5.6	1.6	5.3	1.4	5.2	1.5	0.084	0.139
The thought of using a digital coach as a support for my training sounds: **foolish (1) vs. sensible (7)**	30	5.8	1.4	5.5	1.4	5.4	1.1	0.187	0.223
	32	5.8	1.2	5.2	1.6	5.1	1.5	**0.007**	**0.004**
The thought of using a digital coach as a support for my training sounds: **unpleasant (1) vs. pleasant (7)**	30	5.7	1.4	5.2	1.3	5.3	1.2	**0.047**	0.115
	32	5.4	1.4	5.2	1.2	4.9	1.4	0.264	**0.012**
The thought of using a digital coach as a support for my training sounds: **uncomfortable (1) vs. comfortable (7)**	30	5.8	1.3	5.5	1.2	5.2	1.3	0.136	**0.017**
	32	5.6	1.2	5.2	1.4	5.0	1.3	0.054	**0.016**

5 Discussion

This study focused on the target group of young elderly and examined the changes in self-efficacy regarding PA and exercising. The main research question was: "Does the use of a digital coach affect self-efficacy related to PA and exercising within young elderly?" The study contained 62 participants divided into an intervention group and a control group and was conducted as a 10-week intervention study. The participants in the intervention group used a sport and wellness technology digital coach during the intervention. The data was collected via three online surveys containing items related to exercise self-efficacy, attitude towards using a digital coach, as well as self-efficacy of exercising and improving fitness in general, and the role of sport and wellness technology in exercise.

The 10-week intervention produced the following results: related to exercise self-efficacy, only one item showed a statistically significant change as the members of the intervention group felt more confident that they could restart exercising after having stopped exercising for a while. As to the self-efficacy related to exercising and improving fitness and to the role of sport and wellness technology in exercising, more statistically significant changes could be identified. The perceived need for help for an exercising program was reduced significantly in both the groups. In addition, the intervention group felt more confident to be able to train independently, and it was less hard for them to find out how to improve their fitness. From a theoretical perspective, this result could be seen as an enhancement of the participants' feeling of autonomy.

However, the perceived reliability, accuracy, and truthfulness of sport and wellness technology were significantly reduced among the participants of the intervention group. Thus, the users of the digital coach device (i.e., the intervention group) had a more positive perception of sport and wellness technology in general before the intervention than after it. This might be a result of initial expectations being too high regarding the exactness of the device used in the study, as the use of it during the intervention might have shown inexact results. Still, the perceptions of sport and wellness technology remained on a relatively high and positive level and, although statistically significant, no dramatic changes (from positive to negative) in attitude occurred. However, as the intervention group felt more confident towards independent exercising after the intervention, it can be reasoned that the use of the digital coach had a positive effect on confidence in this part.

Attitudes towards using a digital coach were found to decline in several respects and in both groups of the study. The control group found the use of a digital coach to be a less pleasant, less sensible, and less comfortable idea after the study period. One potential explanation for this is that the members of the control group might have been able to increase their exercising and exercise motivation without a digital coach, and, as a result, see less use for digital coaching than before the study period. The intervention group found the use of a digital coach as less useful and less comfortable after the intervention. This may reflect that the usefulness and comfortableness of digital coaching device were expected to be higher in advance, but these expectations were not fulfilled by the digital coach used in the intervention. However, the attitudes still remained at a relatively positive level. These results are similar to the results of a previous study (Kettunen et al., 2019b) done with a physically less active and younger target group. Overall, based on these quantitative results alone, it is difficult to say what caused the decline in both groups' attitude.

To conclude, as a proxy agent, digital coaching may be a useful approach to support PA and exercise among young elderly, particularly in increasing their perceived confidence in exercising independently. A digital coach can have potential in making young elderly people more aware of how they should improve their fitness. However, certain limitations need to be noted, and more research is needed on the topic.

6 Limitations and Future Research

The results of this study are limited to the selected age group of young elderly and to the selected technology. The participant groups might also have an 'activity' bias as the participants are active participants of the society. The statistically significant declines found in the perceived reliability of sport and wellness technology as well as in the attitude towards using a digital coach call for further research, for example, providing qualitative insights on the topic. It would also be interesting to investigate these effects by using other kinds of digital coaching solutions with different features or different feedback modalities.

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The Ethical Matrix in Digital Innovation Projects in Higher Education

Esther van der Stappen[1] & Marlies van Steenbergen[1]

[1] HU University of Applied Sciences Utrecht, Research Centre for Learning and Innovation, Utrecht, The Netherlands, e-mail: esther.vanderstappen@hu.nl, marlies.vansteenbergen@hu.nl

Abstract Higher educational institutions incorporate projects into their curricula, in which students, together with educators, researchers and professionals from practice, try to find solutions for real, societal problems, to develop relevant skills. Because such solutions are increasingly digital with high impact on society, ethical responsibility is an important part of these skills. In this study, we analyze two cases of digital innovation projects in higher education in which the concept of the Ethical Matrix is adapted and integrated in a Value Sensitive Design approach and applied by educators (case 1) and by students (case 2). We find that an adapted version of the Ethical Matrix supports educators and students in taking values of different types of stakeholders into account which leads to different design choices.

Keywords: value sensitive design, ethical matrix, digital innovation, projects, higher education.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.33
ISBN 978-961-286-362-3

1 Introduction

Innovation is at the core of higher education. Researchers and educators prepare students for an uncertain future in which innovative skills are indispensable. An increasing number of higher educational institutions (HEIs) incorporate multi-disciplinary projects into their curricula in which solutions are sought for complex societal problems. During projects like these, students develop necessary skills such as innovation skills, analytical skills and interpersonal skills (Hero & Lindfors, 2019). In professional practice and research, the rise of the field of Digital Ethics signals the increased importance of ethical skills for innovation. In the overarching Framework for Qualifications for the European Higher Education Area (EHEA, 2018), making ethical judgements and professional ethical responsibility are prominent aspects. Approaches and instruments that stimulate and facilitate ethical design have been subject of study, such as Value Sensitive Design (Friedman, Kahn, & Borning, 2006) and the Ethical Matrix (Mepham, 2000; Mepham, Kaiser, Thorstensen, Tomkins, & Millar, 2006).

In this study, we discuss two cases of digital innovation projects in higher education in which the Ethical Matrix was applied as an instrument facilitating ethical reflection by educators (case 1) and by students (case 2). In both cases, the usage of the Ethical Matrix was performed by non-ethicists within a larger Value Sensitive Design approach. We aim to answer the following research question: "How can the Ethical Matrix augment the Value Sensitive Design approach for digital innovation projects in practice-based research?". After giving an overview of the theoretical background of this study, we describe the methodology and the characteristics of the two cases and present the results of our analysis. Finally, we give our conclusions and discussion and give suggestions for future research.

2 Theoretical Background

In this section, we discuss relevant theory on innovation in higher education and practice-based research, and on Value Sensitive Design and the Ethical Matrix.

Societal challenges need practice-based research in order to obtain innovative solutions to these challenges. This type of research is often performed by universities of applied sciences (UAS). The research questions that underly practice-based research emerge from professional practice and research results have impact both on practice and on the scientific knowledge base. The impact of practice-based research can be described in four types of development (Greven & Andriessen, 2019): development of the knowledge (researching), the system (changing), the product (designing), and of the persons (learning) involved. In this study, we focus on the dimensions of product development (through Value Sensitive Design; see Section 2.1) and personal development (of the ethical skills of the participants).

An increasing number of higher educational institutions (HEIs) incorporate multi-disciplinary projects seeking innovative solutions to societal problems into their curricula. To be successful in such projects, a wide range of skills is needed: innovation skills (such as entrepreneurship and creative problem solving), research skills (such as reflective, analytical and critical thinking), interpersonal skills (such as communication and collaboration) (Hero & Lindfors, 2019) and increasingly, ethical skills. HEIs need to facilitate both educators and students in the development of these skills.

2.1 Digital Ethics and VSD

Nowadays, many innovation projects have a digital core. Digital innovation comes with an increased ethical responsibility of those involved in the innovation process, e.g. in the form of awareness of privacy and inclusion aspects of the technological solution space. The use of a technological artefact can both realize and hinder values. VSD is "a theoretically grounded approach to the design of technology that accounts for human values in a principled and comprehensive manner throughout the design process" (Friedman et al., 2006, p. 349). Human value is defined as "what is important to people in their lives, with a focus on ethics and morality" (Friedman & Hendry, 2019, p. 4). VSD goes beyond instrumental aspects such as functionality,

reliability and ease of use, taking into account also moral values of individuals and societies (Flanagan, Howe, & Nissenbaum, 2008). It not only considers the values of direct stakeholders, but also of stakeholders who may indirectly be impacted by the innovation. For example, future generations or individuals who cannot or will not use a service. The values of all stakeholders, as well as potential tensions between them, are iteratively investigated from a conceptual, empirical and technical perspective. At the conceptual level the relevant stakeholders and values are identified and defined, based on existing literature and knowledge. At the empirical level the perception of these values by the various types of stakeholders is studied by employing methods such as interviews, focus groups or experiments, leading to elaboration of the values into norms. At the technical level values and norms are translated into technical design.

2.2 Ethical Matrix

To lower the threshold for non-ethicists to engage in rational ethical evaluation of biotechnological innovations in agriculture and food production, Mepham developed the Ethical Matrix (Mepham, 2000). Since its conception the matrix has been applied, often in an adapted version, in various settings, such as workshops (Mepham, Kaiser, Thorstensen, Tomkins, & Millar, 2006), research teams (Jensen, Forsberg, Gamborg, Millar, & Sandøe, 2011) and individuals (Kermisch & Depaus, 2018) and in various areas, such as fishery (Kaiser, Millar, Thorstensen, & Tomkins, 2007), waste management (Kermisch & Depaus, 2018) and medicine (Chatfield, 2018). The Ethical Matrix aims to provide an ethically neutral evaluation tool for use by non-ethicists to conduct a comprehensive evaluation of a technological innovation, taking the interests of all relevant stakeholders into account, without specialist ethical training (Schroeder & Palmer, 2003).

The original Ethical Matrix is a 3x4 matrix with stakeholder groups on one dimension and ethical principles on the other (Mepham et al., 2006). The default stakeholder groups are producers, consumers, treated organisms and biota. The ethical principles are based on three main ethical streams: well-being (utilitarianism), autonomy (deontology) and fairness (Rawls). This generic Ethical Matrix can be adapted to the specifics of a particular application area. The cells of the matrix contain the impact, negative or positive, of the technological innovation under consideration on each of the stakeholder groups with regard to the ethical principles.

This impact can be described factually, but how it is weighted in the ethical evaluation depends largely on the values of the participants in the discussion. Over the years, adaptations have been suggested. Vinnari, Vinnari & Kupsala (2017) propose giving more voice to non-human stakeholders. Schroeder & Palmer (2003) suggest adding future generations to the list of stakeholders and replacing the principle of justice (fairness) with the principle of solidarity.

To use the Ethical Matrix in a VSD approach, we made some adaptations. The stakeholders in the original matrix are geared towards biotechnical innovation, leading to other stakeholder groups than encountered in the field of education. As for the dimension of ethical principles, we decided to expand this dimension to all values that emerge from the conceptual investigation step in VSD. The original ethical principles, based on three ethical streams and expressed as the values of well-being, autonomy and fairness, is too limited from a VSD perspective (Friedman et al., 2006). Stakeholders may consider other values as (even more) important. The Ethical Matrix's intended use is evaluation of a proposed technological innovation. Integrating the matrix into a VSD approach opens up the opportunity to also use the matrix during design, for instance to consider various design alternatives within an overall design, or even usage, to evaluate whether the implemented innovation does indeed respect the values it was expected to respect. This adds a third dimension to the matrix, i.e. the design alternative it is applied to (see Figure 1).

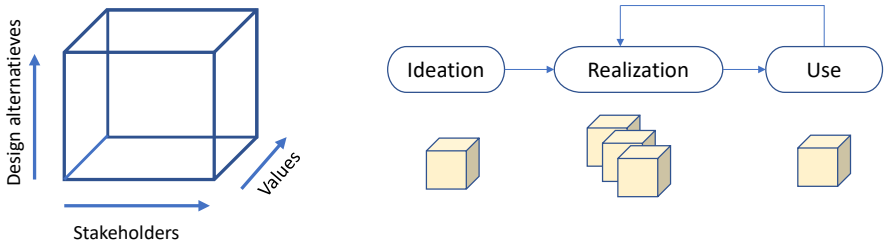

Figure 1: Application of the adapted Ethical Matrix in a VSD approach

The present study shows how our VSD-inspired adaptation of the Ethical Matrix is used by educational professionals (case 1) and students (case 2) in the context of a VSD approach to the design of two apps for students in higher education.

3 Method

For our study, we adopt a qualitative methodology. We analyse two cases (Table 1). We perform the analysis by comparing the two cases on their characteristics along two dimensions: process and product.

Process. We analyze in what way the Ethical Matrix was used in each of the cases in the innovation project: what was the goal of its use and in what way the results of using the matrix have been applied in the innovation process. Furthermore, we analyze who were the users of the Ethical Matrix, what were the instructions and guidance given to them, and how did they evaluate their usage.

Product. Based on the dimensions Product development and Person development of the PRIME-framework (Greven & Andriessen, 2019, we analyze the impact of the usage of the Ethical Matrix. First, we describe the actual data entered in the Ethical Matrix by the participants. Next, we discuss in what way the Ethical Matrix influenced the final products and deliverables of the project. Finally, we touch upon the personal development of the involved users of the Ethical Matrix. In the next two sections, we describe the professional and educational context of the two cases in more detail.

Table 1: Characteristics of the two analyzed cases.

Case	Participants	Role	Domain	Innovation Result
1	4	Educators	Health	Health Check App
2	5	Students	Education	Internship App

3.1 Case 1: Health Check App

HU Clinics, which is part of the HU University of Applied Sciences Utrecht, is a learning environment for allied health students. Under supervision, students deliver care to citizens in the areas of dental care, skin therapy, eye care and speech and language therapy. To create more awareness of 'public health' and prevention (for both citizens and students), an initiative was started to perform Preventive Health Checks in the neighborhood. This entails the presence for a day of students and educators of HU Clinics in a library or neighborhood center where passersby can have a preventive health check performed, without charge and without appointment. After being asked a short list of questions about their basic health and functioning in daily life, citizens can have tests performed from one or more of the disciplines mentioned above. Based on the outcomes the citizen receives an advice, for instance about healthier eating habits, dental care or to go visit an optician. Advices are preventive, the students do not perform a medical diagnosis. To support students in their task of performing the Health Check, the idea arose to develop an assisting app. Besides supporting students in their task, the Health Check App also aims to enable students and educators to work multidisciplinary. It should support all steps in the process, from intake questions, to routing to the relevant disciplines, to performing tests and finally, providing an integrated advice.

3.2 Case 2: Online Internship Coaching

Many HEIs have integrated workplace learning (e.g. internships) into their curricula. The rationale is that graduates with prior work experience are generally considered to have a higher 'employability' (Andrews & Higson, 2008), because they have practiced job-specific functions, such as socialization, innovation and job performance (Nijhof, Nieuwenhuis, & (Eds.), 2008). Learning in the workplace is mostly implicit and unconscious in nature and leads to tacit knowledge (Eraut, 2000). Only few studies aim to design, develop and evaluate technologies that specifically support workplace learning (Siadaty et al., 2012). Recently, a web application was developed to support such learning processes (van der Stappen & Zitter, 2017). This open-source web application provides students with an interface to register their working and learning activities in the workplace in an easy-to-use way, which in turn allows for analytics (a dashboard with charts) and automated feedback, thus giving them insight into their learning process.

To support the internship coaching process performed by higher education professionals, it was decided to add new functionality to this application aimed at partly digitizing the internship coaching process. The new functionality that was developed in this case project, targeted both students learning in the workplace and their coaching educators.

4 Results

In this section, we present the findings of the analysis of the two cases.

4.1 Case 1: Health Check App

The design of the Health Check App was undertaken by four educators involved in the Health Check, during a series of workshops. The workshops were moderated by a research team led by one of the authors. The creation of the ethical matrix, i.e. the identification of relevant values and stakeholders was done in two steps. First, from the literature on preventive health, the research team identified five relevant values: Privacy, Transparency, Trust, Distributive Justice, Informed Consent and Health. This is the conceptual perspective in VSD. Next a philosophical dialogue was held between the four educators, to further elaborate on these values in the context of the Health Check (empirical perspective). Dividing the participants in pairs, each participant was questioned by a moderator about their understanding of and personal norms regarding each of the values. The other participants made notes on post-its, which were clustered per value and discussed by all participants together. In this way a shared meaning was generated. Five additional values emerged from the discussion: Helpfulness, Responsibility, Sustainability, Autonomy and Security. The stakeholders identified by the participants were Students, Educators, Citizens, the Municipality and Employers (the latter three are indirect stakeholders). The resulting matrix was used throughout the design process of the Health Check App.

After a brainstorming workshop, the educators were presented with an overall mockup of the app in a next workshop. Discussing the mockup, they identified potential impacts on the values of the stakeholders, which they wrote down in the cells of the matrix. From this exercise it emerged that the way the advice to the citizen was generated, either automatically by the app or manually by the student, or a combination of the two, would have considerable impact on the values

transparency, autonomy, responsibility and security. The research team designed four alternative mockups for generating advice, varying from the advice being drafted completely by the student to the advice being generated completely by the app. During a following workshop the participants completed an ethical matrix for each of these alternatives, writing down in the cells the impact each alternative would have on the values of the stakeholders.

	Transparancy	**Responsibility**	**Security**	**Autonomy**
Citizen	Orginin of advice is not		May cause sence of insecurity when student heistate a lot a about advice	
Student		High responsibility for student they may not yet be ready for that	May couse sence of insecurtity abaut the soindness of their advice	Much autonomy for students, who formualte advice entirely by thmselves
Lecturer	Process towards advice is not cleat	Requires close monitoring for student	May couse sence of insecurity abaut whether all advices will be sounf	

Figure 2: Part of the Ethical Matrix of one of the design alternatives.

Figure 2 illustrates part of the matrix for the design alternative in which the advice is generated entirely by the student (we only show part of the matrix for brevity reasons). Some cells in the matrix are empty because not every value is impacted for every stakeholder. Comparison of the four matrices showed that a combination between design alternatives 2 and 3, with the app first suggesting relevant pieces of advice, followed by showing other potentially valid advices, represented the best balance between values. As this was the first time the educators worked with the Ethical Matrix, we asked them how they experienced its use, in an informal evaluation. They indicated that working with the matrix enriched their discussions, not only about the app, but also in other work contexts.

4.2 Case 2: Online Internship Coaching

Case 2 was executed by five third-year IT Bachelor students under supervision of one of the authors. Weekly progress meetings were held in which they received feedback on their process and products. The students were instructed to use a VSD approach to develop the new technology and use the Ethical Matrix to obtain a well-thought-out design of the new functionality. The general concept of the Ethical Matrix was explained as a matrix with values as columns and stakeholders as rows which could support them in the design process. First, they consulted VSD literature and they identified four phases for their project: Value Discovery, Value Conceptualization, Empirical Value Investigation and Technical Value Investigation (Spiekermann, 2015). To create the Ethical Matrix, they read VSD literature and interviewed an expert on ethics of digital innovation in education. The stakeholders they identified were Students, Internship Coaches (Educators), Internship Coordinators, App Administrators, and the HEI in general (the last two as indirect stakeholders). The identified values were Privacy, Autonomy, Insight, Efficiency, Support, Responsibility and Usability. The students used the Ethical Matrix for the assessment of design alternatives by students and educators. Because of time constraints, they could not collect direct input from the other identified stakeholders, and they tried to incorporate their values indirectly, mostly by making assumptions.

Design workshops were organized with five internship coaches to complete the Ethical Matrix for seven alternative designs (mockups) for the teacher functionality. The students used the matrix to code stakeholders' opinions in these workshops, by color coding the cells of the matrix: a positive impact was coded as green, a neutral impact as orange, and a negative as red. Next, they invited six students to assess three different designs (online mockups) and coded the review comments with colors in the Ethical Matrix. Based on all gathered information, they reviewed the designs and combined the positively assessed aspects of several design alternatives into final design requirements for the new functionality. The final design facilitated the value Support and Efficiency, while respecting the Autonomy of students.

Interestingly, the students changed the structure of the Ethical Matrix to values as rows and design alternatives as columns, making a separate matrix for each stakeholder. This is probably because they were gathering information from specific stakeholders directly, thus multiple rows for stakeholders were not relevant at that time. This adaptation of the matrix fits with their goal of comparing design alternatives and made it easier for them to incorporate values in the design process, thus easily adapting a design methodology familiar to them into a value sensitive one.

4.3 Comparison of the two cases

As a summary of the above and based on observation and interviews, we compare the two cases on the aspects mentioned in Section 3 in Table 2. The aspects in the shaded rows are similar for both cases; for the other aspects, the two cases differ.

Table 2: Comparison of the two cases on eight aspects.

	Aspect	Case 1	Case 2
Process	Goal	Evaluate and compare design options with regard to values of stakeholders	Evaluate and compare design options with regard to values of stakeholders
	Integration in process	(1) Identifying stakeholders and values in conceptual phase, (2) completing matrix for each design choice.	(1) Identifying stakeholders and values in conceptual phase, (2) completing matrix for each design choice.
	Users	Educators	Students
	Instructions	Moderated workshops	Instructions beforehand
	Usage evaluation	Richer dialogue about design choices	Easily integrated within familiar design process
Product	Data	Impacts on various stakeholder groups as envisioned by educators	Impacts on educators and on students derived from focus groups
	Product influence	Combination of design options that represents best balance of values	Combination of design options that represents best balance of values
	Personal development	Richer, value-sensitive dialogue in other settings as well	Awareness of ethical considerations in design processes

5 Conclusion

Using the Ethical Matrix in a VSD approach to designing innovative apps for higher education, we expanded both the matrix itself and its use: we added more values to the matrix, i.e. all values identified in the conceptual phase of VSD, and we extended its use to all design phases. Our experiences with using the Ethical Matrix in the context of a VSD design project in the two cases described here suggest that the matrix is a valuable addition to VSD. It makes the considerations of the impact of design choices on the stakeholder values tangible and traceable. Furthermore, it provides structure and support to those involved in the design process who have no formal ethical training. Having the participants identify the relevant stakeholders and values themselves, instead of providing them with a pre-structured matrix, made them more aware of the values of different stakeholders. The primary contribution of our study is that it presents one way to operationalize part of VSD accessible to non-ethicists. Our analysis of its application in an educational context indicates that it can be used by both educators and students.

The differences in the way the Ethical Matrix is used in the two cases shows its versatility as an instrument. Of course, comparing merely two cases with a small number of participants has limitations with respect to generalizability. Our next step is to use these experiences to further tune the use of the matrix and try and make it into a generically useful instrument in the performance of Value Sensitive Design.

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TOPICAL RESEARCH CLUSTER OF BLED COMMUNITY – A TEXT MINING APPROACH

NORA FTEIMI[1], MARIKKA HEIKKILÄ[2] & JUKKA HEIKKILÄ[2]

[1] University of Passau, School of Business; Economics and Information Systems, Passau, Germany, e-mail: nora.fteimi@uni-passau.de
[2] University of Turku, School of Economics, Turku, Finland, e-mail: marikka.heikkila@utu.fi, jups@utu.fi

Abstract The number of research publications is growing exponentially, also in the discipline of Information Systems (IS). Evidently, we need new automated means for carrying out extensive inquiries into bodies of knowledge to understand the thematic foci of publications. The aim of this study is to apply an automated cluster analysis as a method of text mining and identify thematic foci of 654 BLED conference proceedings obtained from Scopus since 2005. Subsequently, we discuss advantages and challenges associated with the automatic analysis of huge volumes of texts. Our results support scientists and practitioners to focus future research efforts on these topics and thus help to establish and investigate the identity of the IS discipline, particularly against the background of the growing diversity of topics. The results help the conference to align future calls accordingly. In the future, a prototype can be implemented based on the results to suggest suitable search results.

Keywords: Bled proceedings, research foci, document clusters, text mining analysis, data analysis.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.34
ISBN 978-961-286-362-3

1 Introduction

The need for scientific knowledge for making enlightened societal decisions and for developing goods and services is growing in the society. Simultaneously, the body of scientific literature is growing exponentially. More and more publishers are appearing, new seminars, conferences and publication series introduced – with non-proven scientific record. We are also witnessing a qualitative change in research reporting beyond original, authentic research. Derivative and synthetic reuse of data-sets is increasing, meshing open data from various open sources and reports by automatic analysis and categorization (Buchkremer et al. 2019). Evidently, we need new means for speedy and extensive inquiry into bodies of knowledge, but at the same time, we have to consider the trustworthiness of the sources and reputation of the publishers. In this paper we show a mean to identify the categories of research from a reputable source (i.e., Bled Conference itself), and then discuss its drawbacks and requirements.

The analysis approach we use here is ***text mining*** which is defined as a "*knowledge intensive process in which a user interacts with a document collection […] using a suite of analysis tools*" (Feldmann and Sanger 2007, p.1). Text Mining uses different algorithms and methods from interdisciplinary fields like information retrieval, statistics and natural language processing with the aim of discovering insightful knowledge, new patterns and correlations out of texts. For instance, the analysis outcome can represent semantically related themes, clusters of similar documents, topics with related terms or in the simplest form a frequency count list thus structuring and exploring the text corpus according to certain criteria and objectives.

With its focus on e-related topics, the Bled eConference, which was established in 1988 and has been held annually since then, attracts international interest from researchers and practitioners in Information Systems (IS). The proceedings cover a broad spectrum of established and novel topics that address various facets of social and organizational life, including e-health, e-business, e-government and e-learning. A challenge arising from the increasing amount of textual data is the rapid identification and allocation of publications with similar thematic foci into clusters.

Over the past years, BLED authors applied various methods (e.g., meta-analysis and automated semantic analysis) to investigate the conference topics, its research streams and how they evolved over time (e.g., Clarke 2012; Dreher 2012). With our paper, we will continue contributing to these efforts and present the results of performing a text mining analysis, more precisely an extensive cluster analysis, on 654 BLED conference publications in the time span between 2005 and 2018 (c.f. section 3 for more information about the dataset applied for the analysis). Thus, we define the following research questions for our study:

RQ1: Which topical foci were dominating the proceedings of BLED over the past years and how can these topics be organized according to clusters?

RQ2: What are the requirements and drawbacks of automated analysis of data with methods such as text mining?

The study contributes to research and practice by identifying main research topics, which characterize the research interests of BLED community. We point out prospective future research priorities and deliver the community with an instrument that allows the fast identification of relevant and similar documents according to their topic similarity. The latter can be seen for example as a first step towards implementing an intelligent semantic search engine prototype that suggests similar results and papers to the user and outputs appropriate search results based on the identified topic clusters.

We structure our paper as follows: First, we shed light on selected streams of literature, which contributed to discover the core of knowledge within the BLED community in particular and the IS domain in general (section 2). Subsequently, we provide an overview of the research design applied in this study (section 3). In section 4, we present the main analysis results of the clustering, and then conclude the limitations for using abstract and keyword analysis for recognizing reliable and qualitative different research with implications for further research.

2 Background and Related Work

A first example for the analysis of BLED publications is the study of Clarke (2012), who carried out a long-term analysis of all topics published at the conference between 1995 and 2011. For this purpose, the author examined titles and abstracts of 773 articles in order to elaborate on the topics covered there on the one hand and to examine the impact of the conference in general on the other hand. For this purpose, descriptive information on authorship, citation frequencies and the frequency of article downloads were collected. The thematic analysis was based on the distribution of the articles according to different periods and the examination of the topics dealt with in each period. The author manually grouped these topics subsequently applying a content analysis. This analysis was continued in Clarke and Pucihar (2013) which recognized three phases in the development of research foci of BLED conference: the EDI era (1988 – c. 1995), the period of the Internet and eCommerce (1996 – c. 2004) and the eInteraction era covering web 2.0 and social media (2005 – c. 2011). The authors call for more research going beyond technological interventions and their direct impacts, and to complement economic perspective with personal, community and social perspectives.

With a slightly different focus, Dreher (2012) presented the results of a semantic analysis of the BLED articles between 2001 and 2011. Via a text mining analysis, the author produced a corpus of available full texts and analyzed them automatically using the tool *Rubrico*. The goal of the semantic analysis was to identify embedded concepts and identify terms with related meanings to provide insights into thematic trends, which were present there in latent form. The main finding was that the concept "user" featured strongly in the corpus. A related concept was "people" which was frequently used in health related papers instead of user.

We discuss a third example for the thematic analysis of conference topics within the IS field. Sidorova et al. (2007) thereby use another text mining analysis form, the latent semantic analysis, to examine 1,615 research abstracts published in three top IS journals (*MISQ*, *ISR*, and *JMIS*) between 1985 and 2006 with respect to emerging and declining research topics. Similar to the previously presented studies, the focus was on the temporal differences and dynamics in different time spans. The results show high dynamism of the IS field; new topics replaced the old ones at the top-5

list every five years. The authors used their results to formulate a research agenda, emphasizing the need to pay more attention to the "rigor" factor henceforth.

As a concluding example, we describe the approach of Goyal et al. (2018), who also used latent semantic analysis and methods from the field of natural language processing to identify research topics in IS. With a special focus on four top IS journals (*MISQ, ISR, JAIS* and *JMIS*) and drawing on a previous study of Sidorova et al. (2008), the authors illustrated thematic trends once for the entire corpus and once broken down by the individual journals. A clustering algorithm was finally applied to group the research topics according to eleven corresponding clusters and subsequently assign them manually a label. The top five predominant research themes identified by the authors are knowledge management, technology adoption, e-commerce, recommender systems and security. As an exemplary result of the trend analysis, a high level of activity in the topic of knowledge management was observed for all four journals.

The previous studies indicate how different methods and procedures are used in the IS discipline to address and investigate research themes. Since the focus of our study lies on grouping texts with similar topics rather than on the temporal component, our paper shows how cluster analysis can be used as an effective text mining method to determine clusters of topics based on the documents semantic similarities considered and thus uncover similar topic groups.

3 Research Approach

Our methodological approach for the first research question relies on a text mining procedure in which we have implemented a cluster analysis to classify the documents of our text corpus. We thereby follow the process flow of text mining, which is visualized in Figure 1. The process typically consists of several main phases starting with the project definition and data collection, followed by main text preprocessing steps up to the application and interpretation of the results (c.f., Feldmann and Sanger 2007).

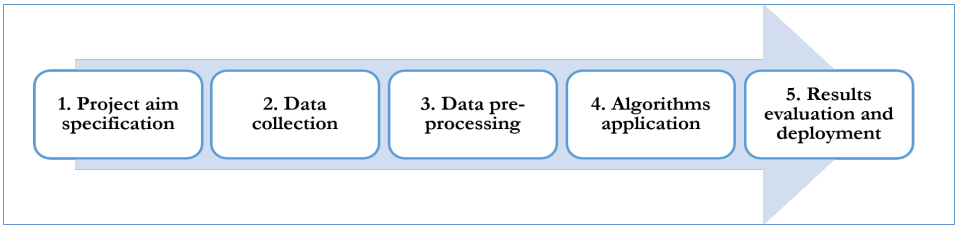

Figure 1: Five phases framework of text mining (c.f., Feldmann and Sanger 2007)

Below we describe the phases of data collection and preprocessing as well as the detailed application of text mining methods by means of the clustering algorithms.

3.1 Data Selection and Corpus Description

We collected our dataset from *Scopus*[1] database, which includes a selection of metadata of 654 articles published in the BLED proceedings (main conference proceedings) since 2005. With reference to Clarke and Pucihar (2013), who describe the new era of interaction from 2005 onwards, we specify this year as starting point for our analysis. Figure 2 shows the yearly distribution of included items and indicates how the number of data items varies per year. However, we point out that these values only reflect the items included in *Scopus* and may therefore differ from the original publication numbers. As our focus lies on analyzing the topical research foci of the conference, we obtained available titles, abstracts and keywords of all 654 data items[2]. As abstracts represent a summary of key findings in the papers, we are confident that our data selection process meets well the analysis purpose. Whereas we used titles and abstracts for cluster analysis, we separately analyzed the keywords to compare both analysis results with each other (c.f., section 4).

[1] https://www.scopus.com
[2] Dataset can be provided on request.

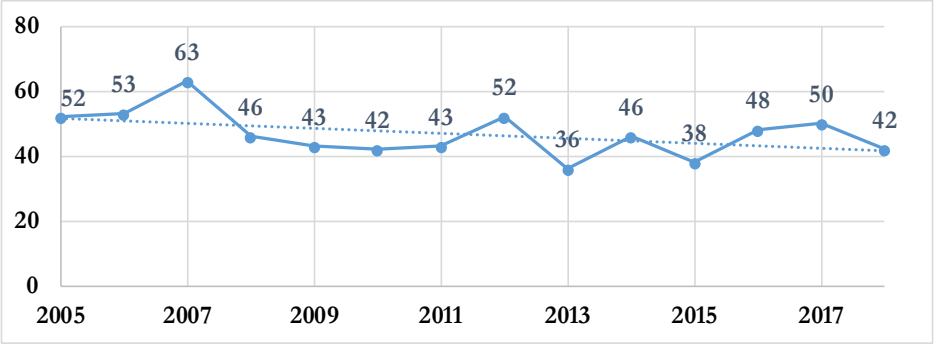

Figure 2: Yearly distribution of dataset (x-axis: years; y-axis: item numbers)

We performed the analysis in the software *R*, an open-source environment for statistical data analysis (Feinerer et al. 2008). For analysis purposes, we built two corpora in R: A first corpus for the running text containing all titles and abstracts (used as input for cluster analysis) and a further corpus containing only all semicolon-separated keywords (used for comparison base with cluster results).

3.2 Preprocessing Steps and Text Mining Analysis

In preparation for the cluster analysis, we undertook some core preprocessing steps of text mining. This included, for example, the harmonization of upper and lower case, the removal of numbers, punctuation marks and stop words, as well as stemming. The latter is crucial to reverse words to their root form and harmonize different word notations.

Subsequently we implemented an agglomerative hierarchical cluster analysis (Zhao et al. 2005) by computing the cosine similarity (Huang 2008) for our dataset, which is a popular measure to compute the document similarity in text mining based on the vector angles (Han et al. 2011). Hierarchical clustering works iteratively, whereby in each iteration step two homogenous documents are merged or clustered based on their similarity. The process ultimately ends with one supercluster. The result of cluster formation in the various iterations is illustrated by a dendrogram representing a cluster tree. The iterative cluster formation was an important reason for choosing this clustering method in this study, as it provides a comprehensive overview of the individual clusters and allows the results to be easily traced and verified stepwise.

Further methods like k-means clustering can be used in the future to compare the results, but their combined use would go beyond the scope of this paper and its topic. We applied *ward's* clustering method (also called minimum variance method) that tends to build compact even-sized clusters (Murtagh and Legendre 2014). This method has wide application in linguistic analysis domains (Szmrecsanyi 2012) and overcomes the drawbacks and computing effort of other clustering methods.

Based on the results of cluster analysis and due to the large number of documents considered in the clustering process, we finally formed groups of superclusters to make the results more comprehensive and to classify them according to key topics. After several iterations in which we varied the number of superclusters, 15 groups of superclusters proved to provide the best and saturated results for the representation of the clustering process. In section 4, we discuss these results.

4 Main Results of Text Mining Analysis

4.1 Clustering Analysis – Supercluster Results and Description

In summary, the application of the clustering algorithm to our corpus led to grouping all 654 datasets based on their thematic similarity. Subsequently, the algorithm formed superclusters in order to summarize the cluster results according to 15 key research topics. Figure 3 shows an excerpt of the overall dendrogram in which four superclusters are illustrated. Each supercluster, represented in the form of colored rectangles, comprises document clusters that are thematically related to the corresponding supercluster. The numbers in the figure represent the respective internal document ID's in the corpus. Each document is labeled using its three top significant terms.

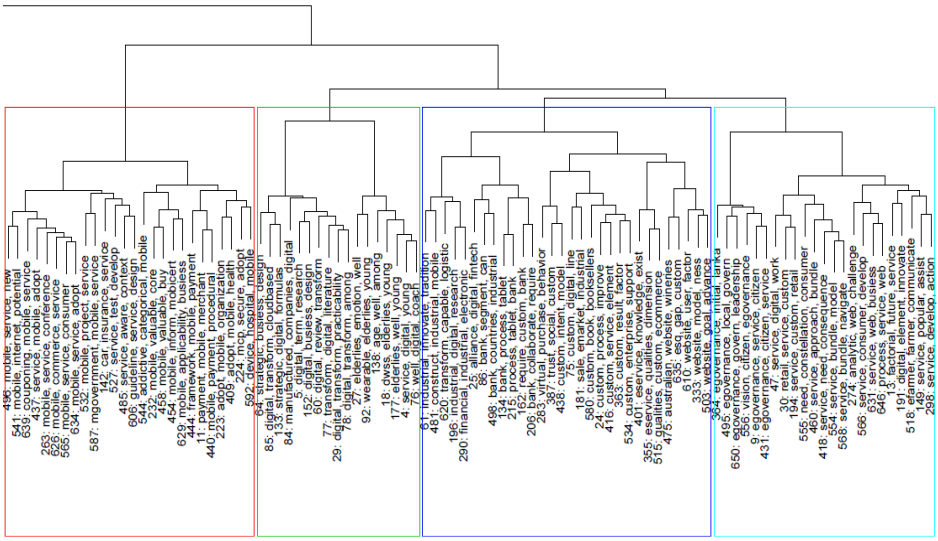

Figure 3: Dendrogram excerpt for 4 out of the 15 superclusters

For instance, the turquoise supercluster on the right represents documents that mainly address the research topic of governance and public administration. In summary, 23 papers were clustered there. This corresponds to 4% of all documents in the corpus. Thus, these documents often deal with the topics of e-governance, leadership processes, (web-based) services e.g., in the agricultural or retailing sector, overall effects on citizens or work procedures in general. The development and use of models for the optimization and implementation of governance structures are also addressed by the related documents.

The blue-bordered rectangle includes all clusters that deal with the research topics of industry and banking. In total, the 30 documents clustered here frequently list terms such as finance, logistics and supply chain, alliances, banking and the purchase or sale of products. Moreover, the virtual orientation of financial services and the use of corresponding technologies as well as the trust of investors and customers into these developments are also covered repeatedly.

Closely related to this topic is the red supercluster (left in Figure 3). Researchers discuss here aspects of cashless payment using mobile technologies, insurance policies and the security of such services in an e-commerce context.

With the green-bordered cluster we were able to identify those documents that are primarily dedicated to the digital transformation and its effects on different generations (e.g., through the use of wearables). The well-being of these person groups is also addressed in this context, e.g., by examining expressed emotions.

In Table 1 we summarize the most prominent results of the cluster analysis. We briefly describe each of the 15 superclusters by outlining the thematic focus of the supercluster and key terms of its related documents. In addition, we summarize how many documents are contained in each supercluster.

Table 1: Research topics and clustering analysis results

ID	Supercluster Topic	Dominant Terms per Supercluster	Paper No.
1	Governance & public administration	E-governance; citizen; service; processes; local; government; retail; consumer; e-farmer	23 (4%)
2	Industry & banking sector	Industry; enterprise; finance; fintech; bank; purchase; logistics; sector; alliance	30 (5%)
3	Digital transformation & generation change	Digital; transform; business; strategic elderlies; young; age	17 (3%)
4	Mobile services	Mobile; service; device; buy; commerce; payment; insurance	26 (4%)
5	Miscellaneous e-business, IT & application areas	Music; sale; workplace; e-business; e-marketplace e-participation; portal; applicability; standardization; knowledge; benefit; trust; evaluate; bitcoin; stock; financial; crowdsource; service oriented architecture; framework; surveillance; data; cloud; reputation; smart	145 (22%)

6	E-Learning & academia	Learn; student; e-learning; course; educate; teach; academia; game-based	18 (3%)
7	Cloud-based collaboration & services	Cloud; adopt; enterprise resource planning; enterprise; change; network; platform; communicate; crowdsource; agile; architectural	61 (9%)
8	Online communities & markets	Communities; virtual; online; market; brand; e-commerce; e-business	24 (4%)
9	E-Commerce adoption & acceptance	Market; e-transformation; e-procurement; economic; adopt; cultural; attitude; game; motivate; incentive; fit; accept	67 (10%)
10	Business-IT alignment & technological trends	RFID; software; inter-organizational IS; e-technology; orchestration; competition; toolmakers; customer relationship management; collaborate; network;	61 (9%)
11	Digital ecosystem	System; information & communication technologies; ecosystem; success; consumer	37 (6%)
12	Big data	Data; analytic; technological; big; platform; open; link; xml	15 (2%)
13	Healthcare	Patient; healthcare; e-health; care; mental; lifestyle; risk	35 (5%)
14	Social media networks & behavior	Social; media; control; network; self-esteem; Facebook; WhatsApp; group; analytic; use	37 (6%)
15	Business models	Business; model; design; business process management; innovation; rule; outsource; interoperability	58 (8%)

4.2 Keyword Analysis

Complementary to the cluster analysis (on titles and abstracts) we separately analyzed the keywords corpus, which BLED researchers used to summarize their papers. Thus, we were able to perform a comparison with the results of the cluster analysis. For interpretation purposes, we consolidated different spelling forms of keywords

(e.g., plural and singular forms, abbreviations) accordingly. Table 2 lists in descending frequency order all terms that occur at least ten times over the entire corpus. In summary, 1,750 unique keywords occur throughout the corpus, of which 51% were mentioned only once. The 15 keywords in Table 2 account for 10% of the overall cumulative term frequency.

Table 2: Keywords in BLED proceedings with a frequency >= 10

Keywords	Term Frequency
Social media, web 2.0	45
Small and medium sized enterprise	28
E-Commerce	25
Business model	24
E-Health	24
Adoption	16
Case study, case survey	15
Cloud computing	15
E-Government	14
Healthcare	13
Trust	12
E-Learning	12
Business model innovation	11
Mobile health	11
Mobile service	10

4.3 Comparison of analyses

Considering Table 2, it is observable that the overall keyword focus lies on topics from the e-business and digital transformation context (e.g., e-health, e-government, mobile service, social media, cloud computing), which is in line with the scope of the conference.

We also find several similarities but also some differences regarding the topics identified in cluster analysis compared to the listing of keywords. For instance, with 45 counts, a predominantly technical keyword "social media/web 2.0" leads the list of keywords. This supports Clarke's and Pucihar's (2013) conclusion that web 2.0 and social media research would dominate the research published in BLED eConference. However, the cluster analysis of the titles and abstracts corpus reveals that the biggest topic cluster (22%) contains miscellaneous research papers on e-business, IT and application areas. The topic "social media", in contrast, represent only one of the smaller superclusters with 6% coverage. Likewise, with 1,750 unique keywords, we find a very heterogeneous set of terms used by the authors to describe their articles.

However, our analysis shows that particular topic clusters – e.g., e-commerce adoption & acceptance (10%), cloud-based collaboration & services (9%), business-IT alignment & technological trends (9%) and business models (8%) – are clearly observable and that BLED authors frequently use certain terms across various papers indicating similar document clusters.

We can also conclude that some results of both analyses are comparable. For instance, similar to the clusters described before, both the superclusters as well as the keyword list deal with hot organizational and technological issues. Electronic service-related topics (e.g., e-governance, e-health, e-business, e-learning) and their coverage in an organizational context (e.g., adoption, trust, success) are dominating in both corpora.

5 Limitations and Future Improvements for Using the Analysis Results

This paper supplemented the previous analysis of Bled eConference papers (Clarke 2012; Clarke and Pucihar 2013) with advanced text analysis methods of abstracts. Even though some similarity with keyword- and abstract-based analysis could be observed in our study, the analysis shows not only discrepancy between the keywords and abstracts, but also lack of data about the research domain, type of data used, nature of studies, and their purposes, all which are of importance when utilizing research results in real world decision-making. As it is now, our analysis provides merely an overview of research subjects.

For publishers' purposes, the above analysis might suffice, but in real life scenarios for decision-making, more information should be provided for the utilization of the results. A journal, conference, or seminar is expected to be scientifically valid and reliable, but this is not always the case (Bowman 2014). Therefore, Masten and Ashcraft (2017) suggest a due diligence of reputable channels for scientific research, but we see the need to go beyond that improvement for the authors, too. As it is evident for the researchers and decision makers to use automated tools for retrieving scientific research, the following measures could be taken:

1) We must provide AI-tools or data scientific -tools full access to texts to find additional information on data, domain, nature of the study, its limitations, etc., because these are too often missing from the abstracts, not to mention keywords.
2) Improving metadata on research.
    a. One way practiced by some journals is to insist for standardized metadata (e.g., standardized abstract revealing purpose, design/methodology/approach, findings, research limitations, theoretical and practical/managerial implications, originality/value and paper type). These are easy to implement in the editorial IS, or complemented by Internet-based questionnaire. Often research projects' *data management plans* can provide this information.
    b. Letting analysis tools to classify the article against the body-of-knowledge automatically, in some cases even without author intervention.
3) Publishers should standardize and gather the information systematically and open it to the public and automatic analyzers.

Regarding our second research question, we conclude that more semantic methods of text mining needs to be incorporated for advanced analytics purposes. The context, in which a certain terminology is used (e.g., the use of negations, sarcasm, slang or the authors' background) and the underlying domain of a text provide important information for analysis, but is difficult to capture using existing automated methods. Manual intervention is therefore often essential. One useful solution that merits further research are domain ontologies, which help to capture the semantic context of similar words, reduce textual and noise and disambiguity (Afolabi et al. 2019).

6 Conclusion

Based on a text mining analysis, we performed an automated cluster analysis on 654 abstracts and titles of BLED proceedings since 2005. Subsequently we compared the results with the keywords provided by the authors of the respective publications. Our aim was 1) to identify research foci of BLED community and 2) to point out drawbacks and requirements of using automated text mining techniques.

Limitations of our work concerns the limited amount of datasets used for the analysis. We deliberately did not include temporal trends, as they were considered in previous work, and focused on the third era of eInteraction (Clarke and Pucihar 2013), in order to determine key research foci in this era. The cluster analysis also leaves some freedom of interpretation, since we have manually labeled the superclusters after performing the automatic cluster analysis and formation of the superclusters. As an unsupervised learning algorithm, this last step of a cluster analysis remains with the analyst. However, since we have carried out the labeling process independently by the authors of the paper, we are confident that it has a reasonable degree of validity.

Concluding, our results show that the community has addressed a broad mix of research topics over the years. In total, we detect 15 superclusters on various topics dealing with different aspects of electronic life. It is also noticeable that many miscellaneous topics (represented by the largest topic cluster no° 5) are addressed.

Methodologically we conclude that the cluster analysis provides first promising results for the classification of semantically similar documents. At the same time, further research is required, for example to develop a comprehensive domain ontology to capture the semantics behind the text. Moreover, the results can be practically implemented in form of a semantic search engine, which supports researchers in finding articles based on the clusters. Such a prototype could, for example, provide users with search suggestions for thematically similar studies by using the thematic clusters and thus generating recommendations and suitable search suggestions based on the similarity of content. The development of a taxonomy or classification scheme would be a further interesting contribution to the harmonization of research topics, as it is already taking place in the IS discipline and its sub-domains (e.g., Knowledge Management). The clusters and assigned terms can

represent the structure of the taxonomy according to which suitable research papers can be delivered. Finally, further analysis methods can also be used based on the cluster analysis, e.g., by means of topic modelling (Blei and Lafferty 2009) to delve deeper into the documents and identify dominant terms.

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THE DATA PRODUCT CANVAS
A VISUAL COLLABORATIVE TOOL FOR DESIGNING DATA-DRIVEN BUSINESS MODELS

MICHAEL FRUHWIRTH[1], GERT BREITFUSS[1] & VIKTORIA PAMMER-SCHINDLER[1,2]

[1] Know-Center GmbH, Graz, Austria, e-mail: mfruhwirth@know-center.at, gbreitfuss@know-center.at, vpammer@know-center.at
[2] Graz University of Technology, Graz, Austria, e-mail: viktoria.pammer-schindler@tugraz.at

Abstract The availability of data sources and advances in analytics and artificial intelligence offers the opportunity for organizations to develop new data-driven products, services and business models. Though, this process is challenging for traditional organizations, as it requires knowledge and collaboration from several disciplines such as data science, domain experts, or business perspective. Furthermore, it is challenging to craft a meaningful value proposition based on data; whereas existing research can provide little guidance. To overcome those challenges, we conducted a Design Science Research project to derive requirements from literature and a case study, develop a collaborative visual tool and evaluate it through several workshops with traditional organizations. This paper presents the Data Product Canvas, a tool connecting data sources with the user challenges and wishes through several intermediate steps. Thus, this paper contributes to the scientific body of knowledge on developing data-driven business models, products and services.

Keywords: data-driven business model, data product development, design-science research, visual collaborative tool, desisgning data.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.35
ISBN 978-961-286-362-3

1 Introduction

The business models of many of today's most valuable firms, such as Google, Amazon, or Uber are heavily relying on data, analytics and artificial intelligence (Seibert and Gründinger, 2018). Likewise, data and analytics hold the potential for business model innovation in traditional organizations. But, "Much less has been written about how, exactly, companies should get started with [using artificial intelligence in business innovation]" (Agrawal et al., 2018).

Difficulties in developing data-driven services are the lack of a structured value proposition and a limited understanding of customer benefits inside the organization (Bertoncello et al., 2018). This means, before starting to develop data-driven offerings, organizations must identify a data product that meets a need from the market (Davenport and Kudyba, 2016). Furthermore, developing data-driven services is a collaborative task, involving knowledge and stakeholders from different disciplines such as data scientists, domain experts and business people. Currently, there are only a few data-focused tools and methods available to support the innovation process (Fruhwirth et al., 2020). Thus, we address the following research question in this paper: *How could a visual representation facilitate collaboration and idea generation for data-driven service ideas for non-data experts?*

In this paper, we propose the Data Product Canvas (DPC), a visual artifact that intends to support the process of developing a data-driven business model, and particularly considers the development of a structured value proposition, understanding of customer needs, and aims to support the necessary interdisciplinary communication. We have developed the DPC in a Design Science Research (DSR) process and present both its development and evaluation in the context of four workshops with practitioners from established organizations. In the evaluation, we studied the (perceived) usefulness and acceptance of the DPC, its actual usage as well as the generated outcome.

2 Conceptual Background

2.1 Data-Driven Business Models, Services and Products

The concept of a business model (BM) basically »describes the rationale how an organization creates, delivers and captures value« (Osterwalder and Pigneur, 2010, p. 14). Data is nowadays often used as a key resource in new BMs to deliver value to customers, so-called »data-driven business models« (Hartmann et al., 2016). One central dimension of a BM is the value proposition. Osterwalder and Pigneur (2010, p. 22) describe the value proposition as »the bundle of products and services that create value for a specific customer segment«. The focus of this BM element is how an organization satisfies customer needs, solves customer's problems, and shows what services and products are offered (Augenstein et al. 2018). The value proposition of a BM can be infused by data and analytics (Schüritz and Satzger, 2016), leading to new data-driven services. Data-driven services use »data and analytics to support the decision-making process of the customer via data and analytics-based features and experiences in form of a stand-alone offering or bundled with an existing product or service« (Schüritz et al., 2019, p.4). Chen et al. (2011) distinguish between two basic types of such service offerings: »Data-as-a-Service« and »Analytics-as-a-Service«. The former describes how data as an asset is offered, whereas the latter comprises offerings that enable customers to analyze large data sets. Next to data-driven services also the concept of »data products« emerged by practitioners (e.g., Glassberg Sands, 2018), as a subset of services. Specifically, data products help their users to make better decisions and formulate customer benefit (Tempich, 2019). The users of a data product can be internal or external customers. To deliver economic value for the product owner, a proper business model is required. The bottom line of those concepts, what we further refer to data products, is that data and analytics are used by a service provider to deliver value to a customer or data user (whereas the customer can be internal or external) to solve a customer problem, specifically supporting his decision-making process via a data product.

2.2 Collaborative Visual Tools for Designing Business Models

Individuals and organizations can be supported in the process of developing new business models through tools and methods (Schneider and Spieth, 2013). Visual tools help to communicate a firm's business model or stimulating collaborative innovation and idea generation (Osterwalder and Pigneur, 2010). There exist a variety of general tools, such as the Business Model Canvas (Osterwalder and Pigneur 2010). Furthermore, there exist also specialized representations for specific business model elements, such as the Value Proposition Canvas (Osterwalder et al., 2014) or specific types of business models (e.g., characterized through the type of key resource), supporting general representations of business models (Kühne and Böhmann, 2019). There is a lack of sufficient tools supporting the development of products and services based on data and analytics (Fruhwirth et al., 2020).

3 Method – Design Science Research

To develop the Data Product Canvas, we conducted a Design Science Research project to develop a new and innovative artifact that helps to solve the real-world problem of generating ideas for data products. We followed the iterative DSR process of Peffers et al. (2007) consisting of six phases as shown in Figure 1: problem identification and motivation; objectives of a solution; design and development; demonstration; evaluation; and communication. The introduction section of this paper addresses the »problem identification and motivation phase«. The second phase, »objectives of a solution«, consists of determining the requirements for developing data products from literature (Sect. 4). The third phase, »design and development«, focuses on how to transfer the requirements into a visual representation (Sec. 5). In the fourth phase of the DSR process, »demonstration«, we apply the developed representation within a pilot setting at a company to demonstrate its applicability (Sect. 4.1). In the fifth phase, »evaluation«, we evaluate the artifact for its usefulness and ease of use within workshops of different organizations (Sect. 6). The last phase »communication« is accomplished via this paper among others.

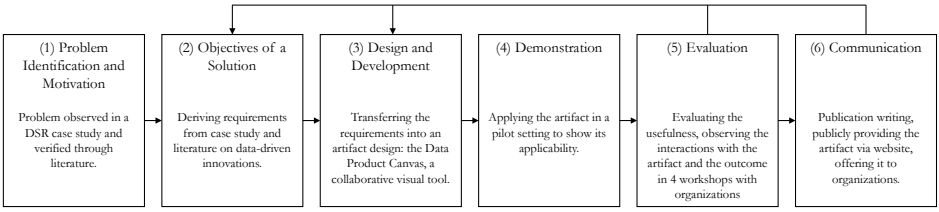

Figure 1: The DSR approach employed in this study (adapted from Peffers et al., 2007).

4 Requirements

4.1 Practical Requirements and Motivation

We have identified the problem within a broader DSR study (Fruhwirth et al., 2019) where the goal was to support a large automotive organization in innovating new data-driven business models. In this study, a one-day workshop with an external consultant organization and 12 participants, where two of the authors also participated, was conducted in 2018 to generate new business ideas based on data. Participants had positions in product management, research management or business development. We observed the need for a visual representation to structure and communicate data-related business ideas during the workshop. After three rounds of open ideation sessions with sticky notes, a generic template was used to further elaborate selected ideas in detail in small groups. The outcome of the workshop was a broad range of »digital business ideas«. Reflecting on the process and the outcome made it clear that especially traditional organizations that now want to go into the direction of data business need clear and structured guidance at the beginning of the innovation process to formulate and communicate business ideas with data. This observation served as the motivation and starting point for this research to develop a visual tool supporting idea generation. After the design phase, the tool was used to structure 21 data-related ideas from the case company. The analysis revealed that the user pains and benefits were not clear in most of the existing ideas, underpinning the need for such a collaborative visual tool supporting idea generation for data-driven services.

4.2 Theoretical Requirements for Developing Data-Driven Services

In order to elaborate design requirements for an artifact that aims to solve the problem of collaboratively developing ideas for data products, we reviewed existing literature on developing data-driven services, products and business models.

Identifying the required data sources is one crucial step within the exploration phase of data-driven innovations (Davenport and Kudyba, 2016; Kayser et al., 2019; Kronsbein and Mueller, 2019). Data can originate from different sources (e.g., internal information systems or free available sources (Hartmann et al., 2016)) or can be classified through different types (e.g. what the data is about (Hunke et al. 2019) or the format of the data (Kayser et al., 2019)). Beyond the diversity of data sources, there is also the challenge of insufficient shared data understanding within an organization when different roles and departments interact or work with the same data (Mathis and Köbler, 2016; Kayser et al., 2019). Making data visible is considered as one approach to address this issue to facilitate discussions for data-driven innovations (Kühne et al., 2019; Kayser et al., 2019). Thus, we frame the first design requirement (DR) for our artifact as follows: *DR-1: The necessary data sources for the data service should be visualized on a conceptual level to facilitate a shared understanding.*

Data itself often has no value for the user. Value is derived from data through the application of analytical methods to generate insights. There are different types of analytics methods for data products (Hunke et al., 2019); such methods can cluster, correlate, recommend, or search data to create meaningful insights that have potential value for data users. The organization should know which tools and methods are appropriate and necessary to generate insights from the data as well as how to interpret the data (Dremel et al., 2017; Kühne and Böhmann, 2019). Therefore, we articulate the second design requirement: *DR-2: The required data analytics methods and activities to generate insights from data should be visible in the artifact representation.*

The aim of using data and analytics by the service provider is to support the data users' decision-making process with the intent to create value for the customer (Schüritz et al., 2019). This means a proper fit between available data sources and user needs is vital for a compelling value proposition (Mathis and Köbler, 2016). Thus, beyond data analytics, data product development also requires customer

intimacy and customer understanding (Wixom and Schüritz, 2017). Service design in general starts from the user perspective, meaning understanding the tasks (»job to be done«), challenges and wishes of the user and map them to the value offering (Osterwalder et al., 2014). Specifically, developing data products requires to bring together the business (customer understanding) and data world (Glassberg Sands, 2018; Mathis and Köbler, 2016) to create a meaningful solution. Thus, we articulate the third design requirement: *DR-3: The pains, wishes and needs of data users that could be addressed by the data product should be visualized to create a meaningful solution.*

The aim of designing data products is to solve the user's problems and address his wishes and needs. However, the provider alone is only creating potential value through the data service and the provider together with the customer is creating real value (Schüritz et al., 2019) through the usage of the data product in the decision-making process of the user. This relates to the concept, that information itself has no value; value results only from its usage (Moody and Walsh, 1999). As the user is at the center of the innovation process, the aspired value for the user should be described (Kronsbein and Mueller, 2019). To understand as an innovation team, how the data product creates what value for the customer through its usage, we articulate the fourth design requirement: *DR-4: The resulting value in use of the data product for the data user should be conceptualized.*

The development model of Davenport and Kudyba (2016) also covers the presentation of the data product. The presentation can have different forms, depending on the level of co-creation between provider and user: In the simplest form, a provider can deliver data through reports, dashboards or APIs, or in more sophisticated form through alerts or benchmarks or even automated decisions (Schüritz et al., 2019). A visual representation should also incorporate that view, i.e. to specify what is exchanged between the provider and the user. Thus, we articulate our fifth design requirement: *DR-5: The type of presentation of the data product should be visualized to conceptualize the data product.*

4.3 Existing Visual Representations for Developing Data Products

After deriving a set of requirements for an artifact that aims at providing a solution to the given problem, we check the requirements against existing visual representations to justify that there is an actual need for a new artifact. We conducted a structured literature review (Fruhwirth et al., 2020), to identify existing visual representations for data-driven innovations in the literature and added three more representations that were published after our search and selection process.

Table 1: Comparison of existing tools based on the identified requirements.

	DR-1 Data Sources	DR-2 Analytics Methods	DR-3 User Wishes	DR-4 User Benefits	DR-5 Data Product
AI Canvas (Agrawal et al., 2018)	✓	✓	(✓)	-	-
Data Canvas (Mathis and Köbler 2016)	✓	-	-	-	-
Data Collection Map (Kayser et al., 2019)	✓	-	-	-	-
Data-Driven Business Value Matrix (Breitfuß et al., 2019)	(✓)	-	-	-	-
Data Innovation Board (Kronsbein and Mueller 2019)	✓	-	✓	✓	-
Data Insight Generator (Kühne and Böhmann 2019)	✓	✓	-	✓	-
Data Value Map (Nagle and Sammon 2017)	✓	✓	-	-	✓
Key Activity Canvas (Hunke et al., 2020)	-	✓	-	-	-
(Hunke and Schüritz 2019)	✓	✓	-	-	-

We checked the representations if they meet the five derived requirements, as shown in Table 1. As our review of previous research shows, no artifact has yet sufficiently solved the problem based on the identified requirements. Specifically, few visual tools incorporate the perspective of connecting data with the user challenges as well as conceptualizing the presentation of the data product.

5 Artifact Description – The Data Product Canvas

To overcome the gap of previous visual tools with data as a specific lense to support the collaborative development of data products, we developed the Data Product Canvas, which is shown in Figure 2. The DPC consists of seven elements: the name of the data product and the name of the customer addressed, highlighting the dyadic view of the provider and customer sphere. On a second level, the artifact consists

of five vertical columns with the elements »data sources«, »data analytics« and »data product« in the provider sphere and »user benefits« and »pains and gains« in the customer sphere. For each element, an icon, a trigger question and illustrative examples are provided. The DPC can be used when an organization in an initiation phase aims to develop ideas for a data product. The canvas is used in a workshop setting with an interdisciplinary team of data scientists, domain experts and management.

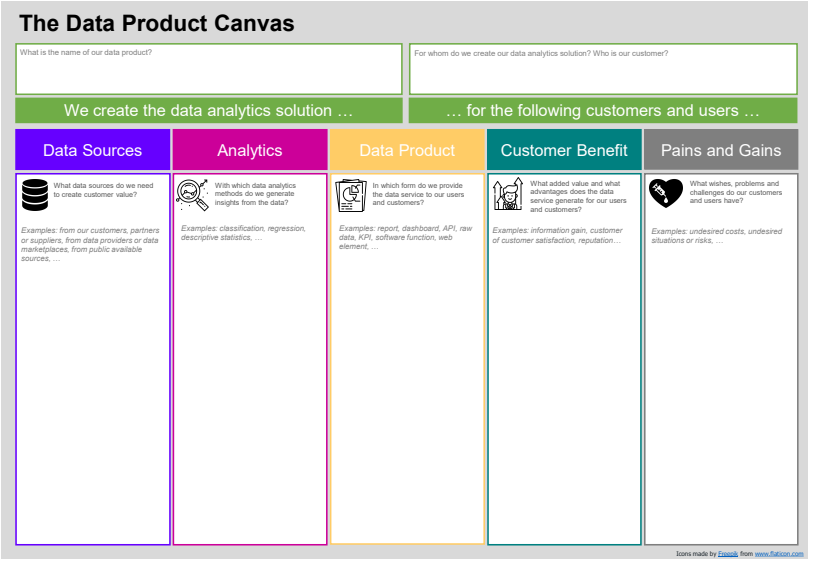

Figure 2: The Data Product Canvas

6 Artifact Evaluation

To complete our DSR project, we have to »observe and measure« (Peffers et al., 2007) how well our artifact supports the design of data products. This involves comparing the objectives of our solution with the observed results from the usage of the artifact (Peffers et al., 2007). In order to do so, we used workshops as an evaluation method (Thoring et al., 2020) to observe the usage of the artifact in cases of idea generation for data-driven business models. We have carried out four workshops with company representatives who are involved in ongoing processes of identifying and concretizing opportunities for data-driven business in their respective companies. Workshop attendance was between 6 and 18 participants;

group work in workshops was carried out in groups of 3-6 participants. Each workshop serves as a case for studying the Data Product Canvas in this paper. Table 2 gives an overview of the evaluation settings, describing the participants, duration and date of each workshop.

Table 2: Overview of evaluation settings of the Data Product Canvas.

Case	Description of participants	Number of Participants	Duration	Date
A	Representatives from green technology firms (e.g., general managers, engineers, innovation managers)	14 participants (4 groups of 3-4 participants each)	~60 min	Mar. 2019
B	Product, innovation, R&D manager and data scientist from an engineering company	6 participants (one group)	~120 min	Aug. 2019
C	IT-manager, data scientist and domain experts from a manufacturing company (e.g., quality, supply chain management or manufacturing)	11 participants (3 groups of 4-6 participants each) [1]	~60 min	Oct. 2019
D	Representatives from green technology firms (e.g., innovation, engineering, management)	18 participants (3 groups of 6 people)	~120 min	Feb. 2020

In order to increase the validity of the evaluation, we used data from different evaluation methods within the workshops, thus facilitating data triangulation: *(i) Observations and notes*: We were taking field notes during workshop, observing and documenting the participants' behavior and their interaction with the artifact. *(ii) Interviews and group discussion*: Participants were asked feedback questions directly after the workshop about the usefulness and ease of use. *(iii) Pictures*: We have documented the outcome (i.e., the filled canvas) of each workshop through pictures, thus enabling a content analysis of the developed ideas. The goal of each workshop setting was to conceptualize an idea for a data product. An initial idea was already provided in each case by the organization beforehand. In cases A, B and C the available data sources were already collected in a prior workshop. In each case, one researcher introduced the canvas and gave initial instructions, whereas a second researcher was observing the participants and taking notes.

[1] Workshops were conducted consecutively; two participants participated in all three workshops.

Overall, the DPC was perceived as useful by all groups and participants. An IT-manager in evaluation case C stated that the canvas was very effective to describe a data use case within a one-hour meeting. He didn't expect to be so fast. A participant in case A mentioned that this representation helps to organize the problem: »You see very quickly where to focus: What do you want? What does the customer want?« (participant in case A, group 2). Furthermore, identifying the user was perceived as a necessary but challenging task: »It took us quite a long time to figure out who our customers were, only then could we continue with the right elements [of the canvas]« (participant in case A, group 2). A data scientist in case C reported after the workshop that they are already using the canvas in their daily work in collaboration with other departments. Similarly, the organization of case B is considering including the canvas into their portfolio of innovation tools.

We have observed different sequences, how the participants filled out the canvas fields. For instance, one group in case A started with the data sources and ended with thinking about what they have to analyze (referring to »Analytics« column). Participants also noted that it was difficult to decide with what column to start. The majority of groups started from the left (»Data Sources«). This approach of using the canvas seems intuitive although no specific starting point was intended through the design. On the other hand, we have observed that participants found it easier to generate a data product idea when starting from the user perspective. Reflecting on all four evaluation settings, we derived the hypothesis that thinking about pains and benefits should be one of the first steps. Thus a further improvement of the canvas should provide guidance where to start.

We have also observed some termination problems: The difference between the category »Benefit« and the category »Pains and Gains« was not clear for several participants in all four cases. There was, for instance, the feedback from one participant that is was not clear what to fill into the column »Benefit«, as the information was in their perception already included in »Data Product« or »Pains and Gains«. Thus, a further improved version of the canvas and workshop format should further clarify those two concepts.

7 Conclusion

This paper presents the Data Product Canvas, a theory-inspired artifact based on requirements derived from literature. We have evaluated the usefulness and ease of use through several workshops with organizations. Overall, our evaluations show that the Data Product Canvas is well perceived, usable and of benefit for organizations and interdisciplinary teams that are initiating a data-driven innovation. The canvas design is the main contribution of this study. Furthermore, we consider the presented artifact as an additional contribution to the knowledge base in the field of data-driven business models and data product development.

Based on the results and contributions of this study, we see a broad range of opportunities for further research. *First*, the artifact could be further evaluated using quantitative measurement instruments. *Second*, further studies could combine the Data Product Canvas with other visual representation, where on the one hand the DPC could provide valuable input for other tools such as the Business Model Canvas (Osterwalder and Pigneur, 2010), or on the other hand, other tools provide information and input for the DPC, such as the Data Collection Map (Kayser et al., 2019) or the Value Proposition Canvas (Osterwalder et al., 2014); and overall contributing to a toolbox for developing data-driven services (Fruhwirth et al., 2020). *Third*, further research could also derive different characteristics for each dimension of the DPC, serving as examples and creativity support during exploration and ideation workshops. *Forth*, further research could have a deeper look at the mental process and the sequence of filling out the fields of the canvas. *Fifth*, further research could also study the role of the canvas as a boundary object and how it facilitates shared understanding between different stakeholders.

This research has two limitations: *Firstly*, the DPC evaluation is not comparative; we, therefore, cannot state whether or how much it is better than any other artifact for supporting the development of data products. On the other hand, the present evaluations have high ecological validity, as they supported exactly the target group in their ongoing tasks, namely company representatives responsible for identifying data-driven opportunities, and developing them in their respective companies who participate in the workshops because this is currently a task for them. *Secondly*, a large part of the workshop evaluation is based on observations and hence the results

might show a bias towards the expectation of the researchers, who are also the designers of the canvas, that the intervention works (confirmation bias).

Acknowledgements

The research based on this paper has received funding from the Austrian COMET Program - Competence Centers for Excellent Technologies - under the auspices of the Austrian Federal Ministry of Transport, Innovation and Technology, the Austrian Federal Ministry for Digital and Economic Affairs and by the State of Styria. COMET is managed by the Austrian Research Promotion Agency (FFG).

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DO YOU KNOW IF I'M REAL?
AN EXPERIMENT TO BENCHMARK HUMAN RECOGNITION OF AI-GENERATED FACES

STIJN KAS[1], THOMAS HES[2], BRIAN JANSEN[2] &
RUBEN POST[1]

[1] HU University of Applied Sciences Utrecht, Institute for ICT, Utrecht, The Netherlands, e-mail: ruben.post@hu.nl, stijn.kas@hu.nl
[2] Utrecht University, Faculty of Science, Utrecht, The Netherlands, e-mail: b.n.janssen@students.uu.nl, t.l.a.hes@uu.nl

Abstract With the development of advanced machine learning techniques, it is now possible to generate fake images that may appear authentic to the naked eye. Realistic faces generated using Generative Adversarial Networks have been the focus of discussion in the media for exactly this reason. This study examined how well people can distinguish between real and generated images. 30 real and 60 generated were gathered and put into a survey. Subjects were shown a random 30 of these faces in random sequence and asked to specify whether or not they thought the faces were real. Based on a statistical analysis, the participants were not able to reliably distinguish between all real and generated images, but real images were correctly distinguished in 81% of cases, where generated images were correctly distinguished in 61% of cases. Some generated images did receive very high scores, with one generated image being classified as real in 100% of the cases.

Keywords: generative adversarial networks, face generation, authenticity, experiment, survey.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.36
ISBN 978-961-286-362-3

1 Introduction

The generation of realistic faces could have many implications for society (Stehouwer, Dang, Liu, Liu, & Jain, 2019). Several examples of where this could have a profound impact can be envisioned. Because faces of people who do not exist have no rights reserved to them in terms of privacy and royalties (Icons8, 2019), the use of human faces in products becomes less bothersome. Additional benefits might be found for purposes such as art, education and even missing persons investigations (Westling, 2019). However, there is reason to be concerned: for instance, a social media-based political campaign used generated faces to create the illusion of legitimacy (Graphika, 2019). With the speed of modern social media, these impressions can have a long-lasting impact, even if the source is debunked afterward (Westling, 2019).

If people cannot distinguish real from generated faces, we as a society may also be faced with some significant problems. There are some proposed methods to detect Generative Adverserial Networks (GAN) generated images automatically (Nightingale, Wade, & Watson, 2017; Xuan, Peng, Wang, & Dong, 2019), but the question is if these can keep up with the pace of development. Nightingale et al. (2017) stress that the importance of this question becomes evident when considering that in today's society we still rely on people to make judgments about image authenticity" (Nightingale et al., 2017). This same sense of legitimacy can be applied for criminal usage, as a generated face will not show up on Google Image search and will, therefore, appear more authentic. There is currently no way to prevent this kind of fraud in the criminal area (Nightingale et al., 2017).

This research aims to provide evaluate the current state-of-the-art face generating To conduct this evaluation, an experiment is conducted whereby thirty faces are shown to participants, where they indicate whether each image is real or generated individually.

2 Background & related work

This section describes the background regarding GAN generated faces and work relevant to determining the authenticity of generated faces.

2.1 General Adversarial Networks

Complex machine learning techniques, deep learning in particular, have much potential to transfer knowledge previously only interpretable to humans over to machines (Bengio et al., 2009). One deep learning method is deep generative models: a method of unsupervised learning which aims to learn better how to predict data. A recent development in this technology was proposed by Goodfellow et al. (Goodfellow et al., 2014). They propose a framework for generative models which makes use of adversarial networks, where the generative model gets an adversary (competitor) to test their method against. This leads to better results as the models keep each other in check. In the framework proposed by Goodfellow et al. (Goodfellow et al., 2014) the model passes noise through a multilayer perceptron (a type of artificial neural network) (Pal & Mitra, 1992) to create randomness, which allows it to generate a new image based on the real world examples it has been taught. This method can be described as an adversarial network, using deep generative models. The synthesis of these methods created Generative Adversarial Networks, which is the technology used to generate the faces for this research.

2.1.1 Related work

There have been multiple studies that have researched methods for successfully recognizing generated fake images with artificial intelligence, machine learning, and other novel detection techniques (Hsu, Zhuang, & Lee, 2020; Kim, n.d.; Stehouwer et al., 2019; R. Wang et al., 2019; Yu, Davis, & Fritz, 2019). Xuan et al. (Xuan et al., 2019) for example propose training a forensics model that can detect GAN generated images on its own. Marra et al. (Marra, Gragnaniello, Cozzolino, & Verdoliva, 2018) managed to detect GAN generated images on social media with a 95% accuracy. A problem with these methods could be that they rely on artificial methods of recognition such as neural networks and other unsupervised learning methods, which means they do not entirely hold a solution that maintains human agency in recognizing what is fake and what is real. These methods could however

still be imperative in combating the negative implications of generated faces mentioned in the introduction.

Whether humans are as of yet capable of recognizing GAN generated faces is still the object of study. Nightingale et al. (Nightingale et al., 2017) proposed a similar research method as this paper, but with more generic images (no faces) that were doctored physically by humans. A website called whichfaceisreal.com has built an experimental design comparable to ours. It is part of an effort to make people more aware of deception: the 'calling bullshit project' (Bergstrom & West, 2019). Sadly it does not seem to use its potential for data collection to analyzing the degree of perceived authenticity of these faces. It is clear this is an angle that still has to be explored in detail. This gap in the state of the art is where this study finds its relevance.

Rossler et al. (Rossler et al., 2019) performed an experiment with a similar set-up as this study. 204 participants were shown either a real image or an image generated by one of five technologies. They were given only between 2 to 6 seconds to observe the image. Subsequently the participants had to indicate whether or not the image was real. Rossler et al. (Rossler et al., 2019) claim to have found a correlation between video quality and the ability to detect whether or not the image was fake. Important lessons can be learned from their experimental setup, namely that variables like image resolution and observer time constraints are important factors to consider. In a study researching manipulated image credibility across platform, Shen et al. (Shen et al., 2019) found photo-editing experience and social media use were significant predictors of image credibility evaluation. In other words, people who were more experienced with social media and photo-editing were better at spotting manipulation. The same may be true for people with experience in facial generation technology and must be taken into account for this study.

3 Methods

This research aims to evaluate the current state-of-the-art face generating algorithms. To formalize this research goal, a research question was formulated:

RQ: How well are humans able to distinguish between real and computer-generated faces?

3.1 Variables

As part of the research design, four independent variables and three dependent variables were formulated.

3.1.1 Independent variables

Timeout Whether a participant has a maximum time of 5 seconds to view the image.
Image Which image the participant is shown and whether this image is generated or not.

General participant information Information about each participant that gives an indication of representation of the taken sample for the population. This information is age, sex, highest received degree, and race.

Technology familiarity An indication of the familiarity of the participant with artificially generated faces and generative adversarial networks.

3.1.2 Dependent Variables

Correctness Whether the chosen answer for a given image is the correct answer.

Response-time Time needed for a participant to decide whether the image is generated or not.

Accuracy confidence An indication of the confidence the participant has that the selected answers are correct.

To complement the experiment, additional knowledge questions were formulated. Of particular interest is the influence of the various independent variables on the dependent variables. More specifically, factors that might influence the correctness DV such as age, race, and familiarity with the technology are to be elaborated, as well as the influence of the added timeout. Lastly, correlations between correctness, response time and accuracy confidence might provide additional insight.

3.2 Hypotheses

Following the research question defined in Section 3 a set of hypotheses is formulated.

Hypothesis 1: People are able to distinguish between real and generated images.

Hypothesis 2: Time pressure affects people's ability to distinguish between real and generated images.

Hypothesis 3: Response time has an effect on people's ability to distinguish between the images.

Hypothesis 4: People can accurately guess how well they can distinguish real and generated faces.

Hypothesis 5: Technology familiarity has an effect on people's ability to distinguish between the images.

Hypothesis 6: There are differences between the demographics

3.3 Method

To conduct the research, an independent measures experiment is conducted whereby each participant is asked to complete the experiment one time the experiment will be operationalized through online survey tool Qualtrics (Qualtrics, 2014). Through Qualtrics, a standardized experiment environment is created, while allowing the experiment to be conducted by the participants without the supervision of the researchers. In the Qualtrics environment, a survey is adapted from a different study, consisting of three sections: general information, facial images and then a set of reflection questions (Mathur & Reichling, 2019).

In the general information section, participants will need to answer general personal information about age, sex, race, and education. Additionally, the participants need to indicate their familiarity with technology to generate artificial faces and generative adversarial networks. Following the general information, the participants first get the instruction page to prepare them for the experiment section. In this section, each participant is shown a random image from a pool of 90 images. The page layout for this experiment section is derived from (Mathur & Reichling, 2019). For the images, three different datasets were used: thispersondoesnotexist.com (P. Wang, n.d.), Generated Photos (Generated Media, n.d.), and Flickr-Faces-HQ Dataset (NVlabs, n.d.). From each of these datasets, 30 random images were selected, meaning 60 images are generated faces and 30 images are real faces. For each image, the participants have to indicate if this image is real or fake. Half of the participants will have a 5 second time limit to view the image, after this time limit the image will disappear and the participant is encouraged to make a decision. At the very beginning of the survey, a random Boolean is generated and saved that indicates if this participant has a time limit. This value is used internally within Qualtrics to determine if a participant will receive a time limit and is used for data analysis.

Ending the questionnaire, the participants are asked what distinctive features made the participants decide whether a face was real or fake. Through this information, an attempt is made to distinguish new opportunities for either improving face generation or improving generated image detection.

3.3.1 Participants

By distributing the experiment through an online platform more participants can be reached. Sampling is mainly achieved through convenience sampling since the researchers are all students most of the participants are expected to be students as well. After data collection a total of 107 unique participants were obtained. However, a large proportion of these responses were not used as they did not pass data cleaning. This resulted in 59 unique participants with a correct response.

3.3.2 Context

Several contextual factors are accounted for through the use of advanced Qualtrics features. Firstly, participants are only able to perform the experiment on a non-mobile device, as asserted by a default Qualtrics feature to exclude all mobile users. Secondly, all participants perform the experiment on a screen larger than 600 by 600 pixels (HD), as asserted by a custom JavaScript setting. Lastly, participants were asked to set their screen brightness to the maximum and set their window to full screen and asked to perform the experiment individually without distraction by other people to minimize differences between participant settings.

3.3.2 Instrumentation

The survey first asks general demographics: age, sex, level of education, race and technology familiarity. Then, an instruction page is shown, explaining the general layout of the experiment. Lastly, the participants are informed their response time is measured and they will be asked about the experiment afterward to see if they found any distinctive features. Once the participant clicks the next button, they will be shown a layout with an image in the center of the screen, two buttons above it, and a title and progress above them. The second part asks how confident they were in discerning the faces. Lastly, two text entries are available, one to ask any questions and one to enter an email to receive the results of the study.

3.3.3 Data collection procedure

With the use of Qualtrics, the data collection procedure is fully automated, and a single URL was used to distribute the survey. To decide whether a participant receives a timeout, a Boolean variable is generated through JavaScript and added as an answer to an invisible question. To iterate through the dataset of 90 images but only show each participant 30 images, Qualtrics' loop and merge feature was used. All images were uploaded as loop and merge entries, and the order was set to random. A timing question was added below the image, automatically recording four values (in milliseconds after the page loaded): 1) first click, 2) last click, 3) page submit and 4) click count. Within the loop and merge JavaScript three settings were added: the title was enriched with a progress indicator, as shown in Appendix C, and if the participant received a timeout, the image would be automatically hidden five seconds after it fully loaded. To compensate for slower internet speeds, the third setting disabled the timing question until after the image was fully loaded. Once the survey is completed, the data is available through the Qualtrics platform, and exported to csv for analysis, as described in Section 4.

4 Analysis and execution

Basic descriptive statistics from the experiment are listed in Appendix E and Tables 2 to 4. Some Likert values had to be recoded from text to an integer. These values are listed in Appendix E. As Appendix E shows, the distribution between timeouts and no timeouts was a little skewed because of the random assignment to participants. Additionally, the participants were between 17 and 60 years old, with most of them between 21 and 26, as shown in Table 2.

Table 1: Age statistics

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
17.00	21.50	23.00	29.36	26.00	67.00	4.00

4.1 Analysis

From the experiment results, four additional metrics were developed. These metrics will be used to answer the research question and analyze the hypotheses. First, to gauge the accuracy of a participants distinction between the real and generated faces, a metric was developed which will be referred to as ”score” from this point on. The score metric was simply calculated by dividing the number of images where the participant got the right answer by the total number of images which was shown to the participant and can essentially be seen as the percentage the participant chose the right answer. Second, in order to analyze whether response time had any effect on the participants' scores, the 'meantime' metric was calculated, by taking the mean of all recorded times which were recorded for that participant. Next, for each participant individually, a metric was developed to measure the correlation between their scores and their time to answer, for each individual image. This was calculated using the built-in correlation feature from R on the participant's time to answer the question and a 1 for right answers and 0 for false. The last metric determined the percentage of real/fake choices per image, again by simply dividing the right options by the total amount the image was shown for each image.

4.2 Hypothesis testing

4.2.1 H1: People are able to distinguish between real and generated images

The scores for each participant gave insight into this hypothesis. As Table 3 shows, the mean of the scores is 0.69, with a standard deviation of 0.12. If people were to random guess each image then the score for each image would be 0,5. When comparing the scores of fake images with a set of data with the same size and all being 0,5 as score a t-test ($t(50)=3.37$, $p=0.00135$) indicates that people are able to distinguish a fake image and are not randomly guessing. This means that the null hypothesis cannot be rejected.

Table 2: General scoring statistics

Value	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	Std.Dev.
Score	0.37	0.60	0.67	0.68	0.77	0.97	0.12
Meantime	1.62	2.70	3.51	3.73	4.27	9.34	1.55
Totaltime	48.55	81.08	105.42	111.89	128.04	280.32	46.42
Real percentage	0.10	0.27	0.33	0.34	0.40	0.53	0.08
True images	3.00	8.00	10.00	10.27	12.00	16.00	2.52
False images	14.00	18.00	20.00	19.73	22.00	27.00	2.52

Additionally, Table 4 shows the difference between the percentage each individual image was chosen as real or fake, for the images that were real and fake respectively. Results of the independent sample t-tests indicated that there was a significant difference in scores for real (M=0.83, SD=0.13) and fake (M=0.61, SD=0.25) images, ($t(87) = 6.07$, $p = 3.218e\text{-}08$).

However, six out of the 59 participants had a score of 0.5 or lower, and were not able to distinguish between the images as a score of 0.5 is equal to chance. The lowest score of 0.37, showed this one participant only choosing the right label in 37% of the images.

Table 3: Real and fake image accuracy statistics

Image	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	Std.Dev.
Real	0.40	0.76	0.84	0.81	0.90	1.00	0.13
Fake	0.00	0.42	0.67	0.61	0.81	1.00	0.25

When the data is looked at individually in detail, some fake images scored remarkably high. One such image fooled all respondents, see Figure 1.

Figure 1: Generated face with an accuracy score of 0%

4.2.2 H2: Time pressure affects people's ability to distinguish between real and generated images

To analyze this hypothesis, a t-test was used based on the scores for participants which received a 5 second time limit and participants who did not. This independent sample t-test indicated that there were significant differences: the participants receiving a time limit (M=0.65, SD=0.098) scored significantly lower than participant not receiving a time limit (M=0.72, SD=0.13),($t(44) = -2.32$, $p = 0.025$). However, the differences in the same groups when comparing the average time each participant took to answer the questions was not significantly different, ($t(39) = -1.83$, $p = 0.075$).

This shows that participants, on average, scored significantly lower when receiving a five second penalty. Additionally, although the difference is not statistically significant, the participants with a timeout were around 18% quicker to decide between the images on average. This conclusion rejects the null hypothesis and affirms the alternative hypothesis: Time pressure negatively affects people's ability to distinguish between real and generated images.

4.2.3 H3: Response time has an effect on people's ability to distinguish between the images

For this hypothesis, the Pearson's product-moment correlation is used because it works well with the available data. The correlation analysis was performed on the average time the participants took to respond and their scores. Results of the test indicated that there was no significant correlation between the mean time and scores, ($r(57) = 0.14$, $p = 0.30$). However, when a correlation analysis is performed on a per-participant basis, and their time to answer is analyzed compared to their correct or incorrect choices, a slight negative mean is found, see Table 5. This is in contrast to what would be expected when looking at the total correlation.

Table 4: Time vs score correlation

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	Std.Dev.
-0.53	-0.22	-0.08	-0.06	0.09	0.37	0.20

A negative correlation means that for images where participants took longer to react, they scored slightly lower on average. This can be interpreted as harder questions taking longer to answer or people's first instinct being better than a nuanced answer, but the data cannot provide the true answer.

Given the results of the Pearson correlation test the null hypothesis cannot be rejected, as there is no significant correlation.

4.2.4 H4: People can accurately guess how well they can distinguish between the images

For this hypothesis, the participants gave an answer to the following question on a 5-point likert scale: "I am confident I was always able to discern which faces were generated and which ones were real".

From this 5 point Likert scale, a correlation analysis was ran compared to their actual score. The results of the Pearson's product-moment correlation test indicated that there was a weak positive association between their answer to the question and their accuracy score, ($r(57) = 0.21$, $p = 0.104$). While there is a positive relation, it is not statistically significant, and therefore the null hypothesis cannot be rejected.

4.2.5 H5: Technology familiarity has an effect on people's ability to distinguish between the images

For this hypothesis, the participants gave an answer to a different question on a 5 point Likert scale: "To what degree are you familiar with technology to generate artificial faces, including generative adversarial networks?".

From this 5 point Likert scale, a correlation analysis was ran compared to their actual score with their familiarity. The results of the Pearson correlation indicated that there was a slightly positive association between their answer to the question and their accuracy score, ($r(57) = 0.16$, $p = 0.23$). While there is a positive relation, it is not statistically significant, and therefore the null hypothesis cannot be rejected.

4.2.6 H6: There are differences between the demographics

For the demographics, three different aspects are investigated: 1) age, 2) gender and 3) education level.

For differences in age results, two correlation analyses were performed: the first Pearson correlation indicated that there was a significant positive association between the participants' age and their time to decide whether the images were real or fake, ($r(52) = 0.31$, $p = 0.020$). The second Pearson correlation indicated a statistically insignificant negative association between the participants' age and their accuracy scores, ($r(53) = -0.25$, $p = 0.06$). Thus, we can conclude that, with statistical significance, older participants scored took longer to make their choices, but did not necessarily score lower.

For gender and education level, two t-tests were performed. The first results for the independent sample t-test indicated that there were no significant differences in scores between males (M=0.67, SD=0.14) and females (M=0.69, SD=0.09), ($t(54) = -0.55$, $p = 0.582$).

For the education level, two groups were formed and another t-test was performed. One group was formed of participants with a bachelor degree or higher and the other of participants without a bachelor degree or higher. This independent t-test indicated that there was no significant difference between students with a bachelor degree or higher (M=0.68, SD=0.11) and students without a bachelor degree (M=0.67, SD=0.13), ($t(39) = 0.44$, $p = 0.664$). Therefore, because the age has a significant correlation with time to decide, the null hypothesis can be rejected.

5 Discussion

In this research, internal validity is fairly well covered. However, some selection bias may still occur during sampling as convenience sampling was the main type of sampling used. Additionally, as the convenience sample originated from students within the IT domain, the sample might be skewed towards IT. Since people in the IT domain are, on average, more familiar with face-generating technology and how to recognize generated faces, this may provide an unbalanced sample. Many external validity threats were mitigated. However, the experimenter effect might still occur if the researcher was present and gave further instructions during the experiment. For this reason, the researchers were vigilant to not instruct the participants more than the instructions given in the experiment. Lastly, since the experiment was performed through an online survey, not all situational and context factors could be accounted for, potentially negatively impacting the reliability of the research.

The findings might be generalizable in a broader sample, as the difference between industries has not explicitly been measured within the experiment. Additionally, one related technology might see similar results in a similar setup: doctored videos. Through use of deep fakes, these videos have risen in popularity and notoriety, and the results might be comparable. Furthermore, the experimental design used in this research is easily adaptable to measuring the same variables for doctored videos.

6 Conclusions and future work

In this experiment, 59 participants iterated through 30 random selected images, where the participant can choose if they think it is real or generated. Based on a statistical analysis, the participants were able to distinguish between real and generated images, but not reliably. Half of the participants were given only five seconds to decide between the images, after which the image disappeared. These participants performed significantly worse than the participants who did not receive such a time limit. How familiar a participant was with face generating technology had no effect on their ability to recognize generated faces, and people who thought they scored well scored a little higher than people who did not. Lastly, correlation analysis showed older participants took significantly longer to decide than younger participants.

While participants were able to distinguish between real and generated images, some individual generated images were thought to be real very often, with one image fooling every participant into thinking it was real. While this does not reject the null hypothesis, it does provide valuable insight: if someone were to use these generated images for malicious purposes, they might filter through them first and pick ones they consider normal looking. If they pick "good" images, people will not be able to distinguish between real and generated images. Because the image selection for this study was performed completely randomly from an image generator this was outside of the scope of this research.

For future work, researchers may manually select images they think are good and compare them to real images, in order to see if they can find different results. Additionally, the experiment could be repeated with a larger, more diverse sample, possibly in an offline, controlled setting. Lastly, the same experimental design could be applied to computer-generated videos such as deepfakes, for which the societal impact is also very high.

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EFFECT OF DIGITAL LITERACY ON THE USE OF DIGITAL TECHNOLOGY: MICRO-ENTREPRENEURS IN THE CREATIVE INDUSTRIES

SUELLEN CAVALHEIRO[1], SHAHROKH NIKOU[1] & GUNILLA WÍDEN[1]

[1] Åbo Akademi University, Faculty of Social Science, Business and Economics, Turku, Finland, e-mail: suellen.cavalheirosilva@abo.fi, shahrokh.nikou@abo.fi, gunilla.widen@abo.fi

Abstract The present study aimed to analyse the role of digital literacy on the intention to use digital technology by professionals in the creative industries. There is consensus among academic literature and governmental reports that creative activities are essential for economic and socio-cultural development. Therefore, there is a need for ongoing research on these segments of industry, such as how they absorb the impacts of digitalisation and improvements in digital technology in their creative and artistic expression. For this latter research, it is required to go beyond the organisational level since these industries are dynamic segments, mostly composed of micro-entrepreneurs and independent workers. Based on an extensive literature review, relationships between the constructs of digital literacy (DL), subjective norms (SNs), compatibility (CP), self-efficacy (SE), attitude towards use (ATT) and intention to use (INT) digital technology were examined for a sample of 163 European creative workers. Structural equation modelling (SEM) was performed and the results showed that DL significantly affects the intention to use digital technology. Moreover, the SEM results showed that the effects of SNs, SE and CP on the intention to use digital technology are mediated through the ATT. Based on the results, theoretical and practical implications are discussed.

Ključne besede: creative industries, creative economy, digitalization, digital literacy, micro-entrepreneurs.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.37
ISBN 978-961-286-362-3

1 Introduction

The recognition of the creative industries as a source of social, cultural and economic development is widely acknowledged in the academic and practical fields. Over the last decades, a number of disruptive changes have occurred in these areas driven by digitalisation and ICT improvements, transforming the work processes of many, if not all, segments of industries. For the creative sector, the competencies required of their workforce have shifted drastically from previous generations. Several studies, such as Kamprath and Mietzner, (2015) and van Laar et al. (2020), have pointed out that creative professionals in the 21st century require a mix of technical skills, mostly ICT related, combined with critical thinking, creativity and problem-solving. The creative industries have become a sector in their own right, with a need to search, encounter, identify, access and evaluate relevant information to generate creative and innovative ideas for the digital environment (Martin, 2005); in other words, this sector has a high need for professionals with digital literacy.

It is important to reinforce that these changes do not nullify Florida's (2002) affirmation about the importance of the creative working class as a key factor for economic development, regional clusters and innovative practices. The change is in the set of skills expected from these workers, where creative knowledge-intensive activities are handled as commodities (Heidemann Lassen et al., 2018). This paper contributes to the academic literature by investigating and reporting on the effect of digital literacy on the intention of creative workers to use digital technology. The digital literacy here is related not only with the ability to find and use information in a digital format, but also to the cognitive process of critical thinking and the capacity for knowledge creation (Chan et al., 2015).

Kamprath and Mietzner (2015) reinforce the need for digital skills at the individual level as a requirement for the future work market. In the creative industries, individual capabilities are highly required, not only because these industrial sectors are particularly characterised by the exploitation of individual creativity (Higgs et al., 2008), but also, for the composition of these segments with a large amount of predominantly small-sized-business entrepreneurs and self-employed workers (Oakley, 2009). Creative professionals offer a unique perspective for the studies in digital literacy, whereupon their technological skills are merged with their individual creative expression. Fundamentally the creative sectors are deeply rooted in

innovation development (Müller et al., 2009), but also the creative workforce can be found in other segments of industry too (Cunningham, 2011). Within the European Union, the creative industries employ about 7.5% of the workforce and add around 500 billion euros to gross domestic product (European Commission, 2017).
In order to put this evidence under analysis and in an attempt to measure the effects of the digital literacy of creative workers, this paper examines the engagement and the consistency of use of these professionals with digital technologies, such as software, applications and services used for graphic design, video editing, web development and photography. The research question addressed in this paper is: *How does digital literacy influence the intention to use digital technology in work processes that rely on the expression of individual creativity?*

2 Theoretical Background

In contemporary society, digital technology skills are intrinsically intertwined with all other sets of abilities required in workplaces and in entrepreneurial activities (De Haan, 2010). The interaction with other people, whether in personal or professional terms, is increasingly being arbitrated by the immediatism of digital applications and devices (Mangematin et al., 2014). Future professional activities will require more and more that individuals can demonstrate a range of abilities that cross with ICT skills. Information literacy is a competence that has been crucial for employees in all economic segments over the last few decades. However, never before has information been accessible in the vast quantity that it is today. In the digital age that we live in today, digital technology provides the medium for communication, immensurable information for strategic business decisions and the means for sharing and self-promoting creative and artistic expression (Hoffmann et al., 2016). In addition to information literacy, digital literacy can be defined as "the ability to understand information and – more importantly – to evaluate and integrate information in multiple formats that a [digital device] can deliver" (Gilster as cited in Pool, 1997, p. 6).

Professionals from creative industries are one of the most meaningful subjects for this research due to their close relationship with creativity, innovation and digital technologies. Previous studies support the intense fluency in digital literacy and capabilities in the use of digital technology that creative workers have and require (van Laar et al., 2019; Nikou et al., 2020). Creative products and services are complex

and are constantly facing imminent risks from a volatile and trend-dependent market (Caves, 2000; Steiner & Prettenthaler, 2015). It is this scenario that drives the creative economy to adhere to new technologies, where knowledge creation is a requirement for the constant renewal of skills imposed on these segments (Kamprath & Mietzner, 2015). Still, more and more organisations are developing work that can see them included in the range of creative industries, by creating new ideas for their segments, generating knowledge and originating new methods to be used as a product or service. Future jobs tend to require a combination of creative content and digital technologies skills (van Laar, 2020). Digitalisation has extreme importance in providing digital environments that support and promote creative work, thus enforcing the importance of digital literacy skills for creative professionals. The empowerment provided by digital technology development is the driving force propelling the creative workforce to seek and maintain digital literacy skills.

3 Hypotheses Development

To measure the effect of digital literacy on the intention of creative professionals to use digital technology, a conceptual model was developed utilising determinants from the conventional theoretical models and the previous academic literature. This paper starts from the assumption that these constructs may have a direct or indirect impact on the intention to use digital technology that may support somehow the effect inflicted by digital literacy. The construct applied here was identified from precedent studies on the use of digital technologies, especially the Decomposition Theory of Planned Behaviour (DTPB) by Taylor and Todd (1995) and the User Acceptance of Information Technology Towards a Unified View (UTAUT) by Venkatesh et al. (2003). The constructs applied here attempt to expand the understanding of the behavioural patterns of the subject in the adoption and use of technology. The theory-based conceptual model presented in this paper is primarily based on the construct factors of these two models: DTPB and UTAUT. In particular, we applied subjective norms (SNs), self-efficacy (SE), compatibility (CP) and attitude towards use (ATT) in addition to digital literacy (DL). The dependent variable in this paper is the intention to use (INT) digital technology. The aforementioned determinants are considered critical in explaining the intention to use digital technology, but, to the best of the authors' knowledge, there has been no study to date in which all these constructs have been modelled together. The conceptual model of this paper can be seen in Figure 1, and the following

subsections explain each of the assumed relationships in light of previous findings from the literature.

For the digital literacy construct, we used the "Digital Native Assessment Scale" (DNAS) proposed by Teo (2013). DNAS was validated and statistically tested to measure the competence level of digital literacy based on the characteristic of digital natives proposed by Prensky (2001). However, it should be noted that other frameworks, such as the EU Digital Competence Framework (Carretero et al., 2018), could be used as an alternative measurement tool. The use of such a framework relies on the availability of the data collected with the subjects under the analysis.

3.1 Subjective Norms

Subjective norms (SNs) refer to the degree of interference of other individuals in the decision-making of the study subject regarding their intention to use a technology (Taylor & Todd, 1995). Its concepts are similar to the "social norms" construct (Davis et al., 1989; Thompson et al., 1991) and the "social influence" construct (Venkatesh et al., 2003). We assumed here that SNs influence the creative professional's behaviour in how others will see the result of their interaction with technology (Venkatesh et al., 2000). SNs influence decision-making in a complex way and are susceptible to a variety of contingent influences (Venkatesh et al., 2003). Previous academic studies suggest that SNs have a greater influence when others have the power to reward or punish an individual's behaviour (Warshaw, 1980). Such statements are also supported by studies related to technology adoption, assuming that SNs are significant in compulsory contexts (Taylor & Todd, 1995; Venkatesh et al., 2000; Venkatesh et al., 2003). This research assumed that the social pressure exerted by SNs influence the attitude of creative workers towards the use of technology; thus the first hypothesis:

H1. Subjective norms have a significant effect on attitude towards using.

3.2 Compatibility

Compatibility (CP) refers to the degree by which the technological tool fits into the individual's reality, adapting to their values, past experiences and current needs (Taylor & Todd, 1995). Compatibility has been proven to be a factor that can influence the attitude towards the use of technology. Such influence is supported by the theoretical DTPB model (Taylor & Todd, 1995). This construct is part of the decomposition of attitudinal beliefs, whereby, according to Taylor and Todd (1995), as attitudinal beliefs tend to increase, the attitude towards the use of technologies tends to be more positive. Thus, the literature supports that compatibility has an effect on how individuals position themselves regarding their intention to use digital technology. Particularly in this paper, we assume that the fit between digital technology and creative professionals' needs and the nature of their work influences the attitude of creative workers towards the use of technology; thus the second hypothesis:

H2. Compatibility has a significant effect on attitude towards using.

3.3 Self-Efficacy

Self-efficacy (SE) refers to an individual's judgment regarding their ability to organise and execute actions in prospective situations (Bandura, 1982). Based on social cognitive theory, in an agentic perspective, Bandura (1982) argues that individual characteristics, such as personality, situation, environment and behaviour, reciprocally affect each other. The author also states that self-efficacy is a facilitator that drives action, considering that it increases motivation, strengthens resilience in the face of adverse experiences and reduces anxiety (Bandura, 2010). Reaffirming Bandura's states, other studies, such as Vijayasarathy's (2004), have assumed that an individual's likelihood of engaging in a particular behaviour is closely related to the expectations of their ability to perform it. Bandura (2012) states that with each new action that takes place, self-efficacy positively reinforces its relationship with the subsequent action, increasing over time. Compeau and Higgins (1995) made use of self-efficacy within the context of digital technology use. This research assumed that the self-efficacy of creative professionals influences their attitude towards technology use; thus the third hypothesis:

H3. Self-efficacy has a significant effect on attitude towards using.

3.4 Attitude Towards Using

Attitude towards using refers to the affective reaction of an individual when using technology (Venkatesh et al., 2003). The attitude towards using is associated with the individual's liking, joy and pleasure when using technology (Venkatesh et al., 2003). For some cases, the construct may represent the strongest predictor of behavioural intent (Nikou et al., 2019; Venkatesh et al., 2003). More detailed analyses have indicated that attitudinal constructs regarding the use of technology are more significant when the theoretical model considers constructions related to the expectation of effort and performance (Venkatesh, 2000). This research assumes that attitude towards using influences the creative workers' intention to use digital technologies; thus the fourth hypothesis:

H4. Attitude towards using has a significant effect on the intention to use digital technology.

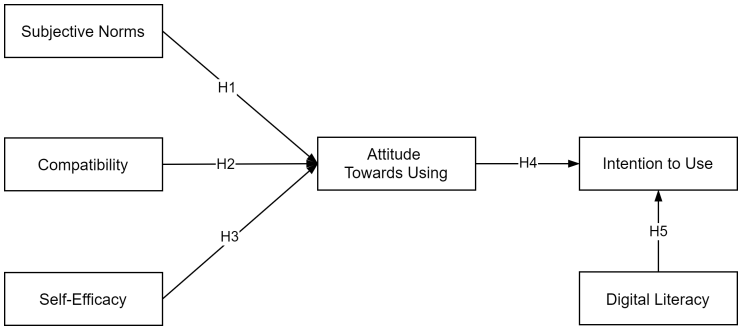

Figure 1: Research model.

3.5 Digital Literacy

Digital literacy refers to the attitude and ability of individuals to appropriately use digital technology to identify, access, generate, integrate and evaluate digital resources, building new knowledge, creating media expressions and communicating with others (Martin, 2005, p. 135). An individual is considered digitally literate when they can demonstrate technical and operational skills to use digital technology in

their daily activities (Ng, 2012). The digitally literate individual should be a critical thinker, who can responsibly make use of the Internet, who can select software appropriate to their needs and use it with the capability to seek and evaluate digital information for learning and performing tasks (Ng, 2012, p. 1068). To better understand the level of digital literacy of the creative worker professionals, this study used the Digital Natives Assessment Scale (DNAS) by Teo (2013). This research assumes that digital literacy directly influences the creative workers' intention to use digital technologies; thus the fifth hypothesis:

H5. Digital literacy has a significant effect on the intention to use digital technology.

3.6 Intention to Use Digital Technology

The intention to use a technology refers to the degree to which an individual would like to use the technology in question in the future (Joo et al., 2018; Nikou et al., 2018). This construct is related to motivational factors, which makes it the most crucial determinant in predicting the decision to take a specific action (Ajzen, 1991). In this research, the intention to use was considered as a dependent variable.

4 Methodology

The methodology employed in this paper focused on developing a better understanding of the influence of digital literacy on the intention of creative workers to use digital technology as part of their work processes. Thereby, a quantitative approach was applied through performing Partial Least Squares Structural Equation Modelling (PLS-SEM) using Smart-PLS software. The PLS-SEM method has been widely applied in academic research focusing on a casual–predictive approach (Hair et al., 2019). It is also considered relevant to perform SEM analysis with forecasting statistical models with the aim of producing casual explanations (Sarstedt et al., 2017). All the constructs used in the present research were used in other academic studies and have been previously tested, thus ensuring the reliability of our data measurement. All our research items used within each construct were also selected from validated measures, undergoing minor wording adjustments by the authors to better fit the context in which this research proposes to perform our analysis, see Appendix 1. Items for measuring subjective norms (n = 5), compatibility (n = 4) and self-efficacy (n = 4) were derived from Taylor and Todd, (1995). The attitude

towards using (n = 5) and intention to use digital technology (n = 5) were derived from Taylor and Todd (1995) and Venkatesh et al. (2003). Lastly, digital literacy (n = 12) was measured with items based on the digital native assessment scale (Teo, 2013). The choice and application of an online questionnaire were based on accessibility and ease of collecting quantitative data, enabling the researchers to perform data measurement efficiently. All the survey items were measured on a 7-point Likert scale from "1 = strongly disagree" to "7 = strongly agree".

4.1 Data Collection

The sample of participants was limited to creative workers who perform their artistic activities through the use of digital technology. Within this group, only micro-entrepreneurs and the self-employed were included. A total of 50 employees in the firm was considered as a delimiting factor for the participation of micro-entrepreneurs in this study, thus representing a small-sized business. This was a strategic decision in order to ensure selecting creative workers that were outside of the reality imposed by large corporations, as the environment imposed by large companies can limit the use of digital technology or it may be dictated by commercial agreements not related to creative professional ability or interest in digital technology. The profiles of these creative workers were found by the exposure of their online portfolio or through online platforms and communities developed for the dissemination of creative work (e.g. Behänce, Dribbble, GitHub, among others). The choice of these professional profiles was random, given the need to include different genres, occupations and national territories within Europe. In July of 2019, a questionnaire was distributed by email invitation to a total of 1486 European creative workers who presented the following characteristics: (i) currently working as a creative worker, positioning oneself as the creator of their own work, (ii) identify oneself as a freelancer, self-employed, start-up, studio or group of independent artists, (iii) the work created by one must be unique, that is, must represent an original perspective that embodies the vision of the creator and (iv) for the cases of micro-entrepreneurs, no signs should be found that the company belongs to or is part of a medium or large business.

5 Data Analysis

A total of 166 questionnaires were returned, resulting in a response rate of approximately 11.5%; however, within that number, 3 participants did not answer the questionnaire properly and were excluded from further analysis. As suggested by Armstrong and Overton (1977), the non-response bias test was performed. The first 25% of respondents were compared with the final 25% of respondents for all survey items using the chi-square test. The result showed that the participants did not differ significantly, thus allowing us to conclude that the answers collected from the sample were not biased. Of the respondents, 66.8% were males, 31.2 % were females, and 1.8% did not mention their gender. Gender unbalances with similar proportions were also reported in recent studies that made use of the same online platforms and communities to showcase creative work as utilised in this study (Hemsley & Tanupabrungsun, 2018; Kim, 2017). The respondents were geographically distributed among 25 countries in Europe, with the majority from Nordic countries. The broad participation of subjects for Nordic countries could be related to the geolocation of the authors. It could be associated with the time zone from where the emails were sent, facilitating their open-rate and consecutively the survey being answered. When we asked whether the respondents had migrated from their original country where they were born, only 30.7% said yes. The majority of the respondents were full-time freelancers (38%), and 32.5% reported that they were full-time employed as an entrepreneur. The majority of the respondents had at least six years or more experience working as an artist or as a creator, see Table 1.

Table 1: Descriptive statistics of the respondents.

Descriptive Statistics	Pooled Sample	Female (%)	Male (%)	Others (%)
Sample Size	163 (100%)	51 (31.2%)	109 (66.8%)	3 (1.8%)
Median Age	34 years	32 years	35 years	33 years
Migrated from the Place of Origin				
Yes - Reside in a different country	50 (30.7%)	17 (10.4%)	32 (19.6%)	1 (0.6%)
No - Reside in the origin country	113 (69.3%)	34 (20.9%)	77 (47.2%)	2 (1.2%)
Level of Education				
High School Diploma	23 (14.1%)	4 (2.5%)	19 (11.7%)	0 (0%)
Bachelor's degree	81 (49.7%)	25 (15.3%)	55 (33.7%)	1 (0.6%)
Master's degree	44 (27%)	22 (13.5%)	20 (12.3%)	2 (1.2%)
Ph.D.	14 (8.6%)	0 (0%)	14 (8.6%)	0 (0%)
Other	1 (0.6%)	0 (0%)	1 (0.6%)	0 (0%)
Employment Type				
Full-time as a freelancer	62 (38%)	22 (13.5%)	40 (24.5%)	0 (0%)
Full-time as an entrepreneur	53 (32.5%)	15 (9.2%)	37 (22.7%)	1 (0.6%)
Part-time as freelancer and entrepreneur.	13 (8%)	4 (2.5%)	9 (5.5%)	0 (0%)
Part-time as a freelancer.	33 (20.2%)	8 (4.9%)	23 (14.1%)	2 (1.2%)
Part-time as an entrepreneur	2 (1.2%)	2 (1.2%)	0 (0%)	0 (0%)
How long have been working as an artist/creator				
Less than 2 years	12 (7.4%)	7 (4.3%)	5 (3.1%)	0 (0%)
From 2 to 5 years	46 (28.2%)	16 (9.8%)	29 (17.8%)	1 (0.6%)
From 6 to 10 years	48 (29.4%)	17 (10.4%)	30 (18.4%)	1 (0.6%)
From 11 to 15 years	29 (17.8%)	5 (3.1%)	24 (14.7%)	0 (0%)
From 16 to 20 years	19 (11.7%)	4 (2.5%)	15 (9.2%)	0 (0%)
More than 21 years	9 (5.5%)	2 (1.2%)	6 (3.7%)	1 (0.6%)

In Table 2 below, it is possible to analyse the self-perception of the respondents regarding their frequency of use and proficiency with creative digital work tools by gender. Female respondents tended to have a higher score on the DNAS than male respondents. However, regarding the level of expertise in digital applications, male respondents tended to score higher than the female respondents regarding all the applications selected for the questionnaire.

Table 2: Respondents' self-perception of their frequency of use and proficiency of creative digital technology.

Descriptive Statistics	Pooled Sample	Female (%)	Male (%)	Others (%)
Sample Size	163 (100%)	51 (31.2%)	109 (66.8%)	3 (1.8%)
Digital Native Assessment Scale (DNAS) 12-Items				
(7-point Likert scale from "1 = strongly disagree" to "7 = strongly agree")				
Grow up with Technology	M = 6.49	M = 6.54	M = 6.46	M = 7.00
Comfortable with Multitasking	M = 6.27	M = 6.31	M = 6.25	M = 6.11
Reliant on Graphics for Communication	M = 4.36	M = 4.66	M = 4.19	M = 5.44
Thrive on Instant Gratifications	M = 4.84	M = 4.99	M = 4.74	M = 5.78
Please indicate how often do you use the following digital technologies (hardware)				
5-point Likert scale from 1 = "I do not use it" to 5 = "several times a day"				
Smartphone	M = 3.94	M = 3.96	M = 3.94	M = 4.00
Smartwatch	M = 1.42	M = 1.41	M = 1.40	M = 2.00
Desktop Computer	M = 3.09	M = 2.75	M = 3.25	M = 3.00
Laptop Computer	M = 3.25	M = 3.51	M = 3.13	M = 3.33
Tablet Computer	M = 2.13	M = 1.92	M = 2.20	M = 3.00
Laptop Tablet Hybrid (e.g., Surface Pro)	M = 1.25	M = 1.10	M = 1.33	M = 1.00
Graphics Tablet (e.g., Wacom Intuos)	M = 2.69	M = 2.61	M = 2.74	M = 2.33
Professional Camera	M = 1.95	M = 1.98	M = 1.95	M = 1.33
Please indicate how often do you use the following digital technologies (software)				
(5-point Likert scale from "1 = I do not use it" to "5 = several times a day")				
Raster Graphics Editor (e.g., Photoshop)	M = 3.60	M = 3.57	M = 3.61	M = 3.67
Vector Graphics Editor (e.g., Illustrator)	M = 2.70	M = 2.90	M = 2.61	M = 2.67
Motion Graphics Editor (e.g., After Effects)	M = 1.71	M = 1.61	M = 1.75	M = 2.00
Video Editor (e.g., Premiere)	M = 1.54	M = 1.33	M = 1.63	M = 1.67
3D Modelling Editor (e.g., Cinema 4D)	M = 1.69	M = 1.47	M = 1.80	M = 1.33
Code Editor (e.g., Visual Studio)	M = 1.33	M = 1.22	M = 1.39	M = 1.00
Team Collaboration App (e.g., Slack)	M = 2.08	M = 2.14	M = 2.06	M = 2.00
Task Management App (e.g., Asana)	M = 1.61	M = 1.65	M = 1.59	M = 2.00
Version Control App (e.g., GitHub)	M = 1.40	M = 1.31	M = 1.46	M = 1.00
Please indicate your expertise level using the following digital technologies (software)				
5-point Likert scale from 1 = "novice" to 5 = "expert"				
Raster Graphics Editor (e.g., Photoshop)	M = 4.31	M = 4.04	M = 4.43	M = 4.67
Vector Graphics Editor (e.g., Illustrator)	M = 3.41	M = 3.35	M = 3.43	M = 3.67
Motion Graphics Editor (e.g., After Effects)	M = 2.09	M = 1.75	M = 2.23	M = 3.00
Video Editor (e.g., Premiere)	M = 2.12	M = 1.73	M = 2.29	M = 2.67
3D Modelling Editor (e.g., Cinema 4D)	M = 2.04	M = 1.69	M = 2.19	M = 2.67
Code Editor (e.g., Visual Studio)	M = 1.45	M = 1.24	M = 1.57	M = 1.00
Team Collaboration App (e.g., Slack)	M = 2.29	M = 2.25	M = 2.32	M = 2.00
Task Management App (e.g., Asana)	M = 1.71	M = 1.71	M = 1.71	M = 2.00
Version Control App (e.g., GitHub)	M = 1.39	M = 1.24	M = 1.48	M = 1.00

5.1 Measurement Analysis

The research model was analysed in two different stages: (a) measurement model assessment and (b) structural model assessment. The assessment of the reliability and validity was achieved through the outer loadings, composite reliability (CR) and average variance extracted (AVE). According to Hulland (1999), the values of the outer loadings should be above .70, here most indicators loaded above, with a few

exceptions under this value. For the CR values, which is the assessment of the internal consistency, only SNs (.68) displayed a value below .70, while the other constructs showed values above. The AVE values for all constructs were above the recommended value of .50 (Bagozzi & Yi, 1988), see Table 3.

Table 3: Reliability and validity.

	Factor Loadings (lowest-highest)	Cronbach's α	CR	AVE
Attitude Toward Using	.74-.89	.84	.90	.68
Compatibility	.74-.88	.79	.87	.70
Digital Literacy	.69-.81	.71	.82	.53
Intention to Use	.68-.83	.78	.86	.60
Self-Efficacy	.80-.85	.85	.90	.70
Subjective Norms	.68-.84	.68	.81	.59

Note: CR = Composite reliability; AVE = Average variance extracted.

For the discriminant validity, we used the square root of AVE for each latent variable to establish the discriminant validity (Fornell & Larcker, 1981). All the values were higher than the other correlation values among the latent variables, with the values shown in bold on the diagonal in Table 4.

Table 4: Discriminant validity.

	ATT	CP	DL	INT	SE	SN
Attitude Toward Using	**.83**					
Compatibility	.66	**.84**				
Digital Literacy	.42	.52	**.73**			
Intention to Use	.77	.60	.51	**.78**		
Self-Efficacy	.62	.71	.56	.57	**.83**	
Subjective Norms	.51	.37	.26	.43	.35	**.77**

5.2 Structural Analysis

The SmartPLS software was used to assess the significance of the relationships between the constructs in the model. The SEM results showed that the intention to use digital technology was explained by a variance of almost 63%. The construct attitude towards using digital technology was explained by a variance of 54.5%. The PLS-SEM analysis showed that the attitude towards using (ATT) digital technology had a strong effect on the intention to use digital technology ($\beta = .67$, $t = 10.13$, $p < .001$). The impact of digital literacy (DL) on the intention of creative workers to use digital technology was significant ($\beta = .21$, $t = 2.74$, $p < .010$). Therefore, hypotheses **H4** and **H5** were supported by the model. The relationships between social norms

(SNs) (β = .27, t = 3.91, p < .001), compatibility (CP) (β = .24, t = 4.18, p < .001), and self-efficacy (SE) (β = .26, t = 2.84, p < .05) on the attitude towards using digital technology were found to be significant. Respectively, **H1**, **H2** and **H3** were supported by the model. The results can be seen in Figure 2.

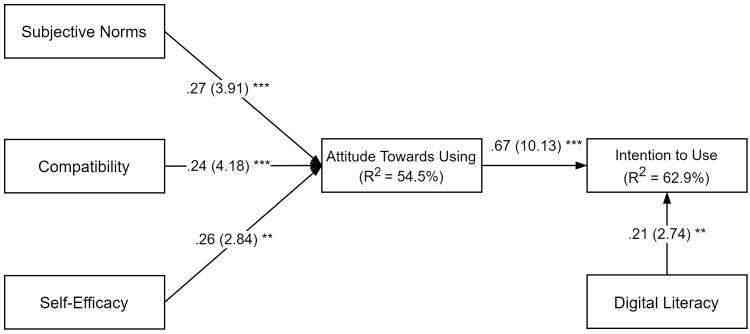

Figure 2: Structural model results.

5.3 Multigroup Analysis (MGA)

The scores on the Digital Native Assessment Scale (DNAS) (Teo, 2013) were used to classify the respondents into two groups: high score and low score. Due to the high average score found among the respondents, we performed the DNAS analysis in a mean-split of the registered score, the high score group (above the mean; n = 93) and the low score group (below the mean; n = 70). The MGA results showed that the main difference between these groups was the path relationship between the SE (β = .19, t = 1.49, p > .001) and the attitude towards using digital technology, such that this path was not significant for the high score group. It can be presumed that SE had a decreasing effect on ATT for those with higher digital literacy level. In the MGA for groups divided by gender, the female participants showed many distinguished path relationship differences. The most meaningful was the path between digital literacy and the intention to use digital technology, which was not significant for females, but it was for males. The significant difference between females and males regarding the digital literacy path requires an in-depth investigation, which unfortunately, the analysis of these constructs alone cannot fully explain. Another interesting group that was possible to explore was that related to the Nordic countries' citizens (n = 73) in comparison with non-Nordic countries citizens (n = 90). For Nordic countries citizens, the path between CP to the attitude

towards using digital technology was not significant. While for those respondents that were not Nordic countries citizens, the SE effects on their attitude towards using digital technology were not significant. Similar results were found on the high score group as classified by DNAS.

5.4 Mediation Analysis

A mediation analysis was performed to better understand if the construct attitude towards using digital technology mediated the path relationship between subjective norms, compatibility, and self-efficacy with the intention to use digital technology. The results of the specific indirect effects showed that the effects of SNs ($\beta = .18$, $t = 3.40$, $p < .05$, CP ($\beta = .24$, $t = 3.83$, $p < .001$) and SE ($\beta = .17$, $t = 2.80$, $p < .05$) on the intention to use digital technology were mediated by the attitude towards using digital technology.

6 Discussion

In this paper, we examined the role of digital literacy on the intention to use digital technology for creative professionals. An integrated conceptual model was developed composed of six constructs. The path between digital literacy and the intention to use digital technology was proven to be significant for the study sample of 163 European creative professionals. The SEM results showed that subjective norms, self-efficacy and compatibility all have a direct and positive impact on the attitude towards using digital technology. The use of the Digital Native Assessment Scale (DNAS) measurement tool from Teo (2013) was valuable in the classification of the respondents in groups with a lower score above the mean and higher score above the mean. It is relevant to highlight here that the mean score for the participants was 66 points in the DNAS, which in this study represents a total of 79% of the maximum score possible. Overall, the creative professionals that participated in this research demonstrated a meaningful level of digital literacy, and it was shown that their perception of digital literacy had a direct effect on their intention to use digital technology. The multigroup analysis results showed that the path between digital literacy to the intention to use digital technology was not significant for the female participants. In this case, the results could be inconclusive due to the low number of female respondents, however, a more accurate analysis is required for better comprehension of the causes of these results. In a general matter,

the skills in digital literacy proved to be essential for the group of creative workers in the analysis. The results found in this paper complement the findings of previous studies (e.g. Müller et al., 2009; Mangematin et al., 2014; Kamprath & Mietzner, 2015; Nikou et al., 2019; Nikou et al., 2020; van Laar et al., 2019; van Laar et al., 2020), which also indicate the close relationship of creative activities with innovation and ICT-related skills.

7 Conclusion and Future Work

The dynamic integration of digitalisation and digital skills with creative activities has resulted in a need for constant adaptations in creative professionals' level of digital literacy. These segments of industries are strongly related to knowledge-intensive activities, where innovation in technological developments can influence and modify the way these workers practice their work processes. Digital information processes, critical thinking and problem-solving are essential skills (referred to as digital literacy) for the exploitation of their creative expression. This paper proposes a modelling analysis of the effects of digital literacy on the intention to use digital technology. The outcomes support previous results reported in the academic literature (Nikou et al., 2020). Future work should explore in depth the subgroups found here, building on the analysis presented in this paper. There is also a need to encourage test experiences to validate these observations, where creative professionals not only self-report but also demonstrate the digital literacy skills evidenced in this study. Future works should also take into consideration that more and more industrials segments are tending to rely on the exploitation of individual creativity using ICT-related skills that require a high level of digital literacy. There is a necessity to encourage an environment where workers can embrace and learn new digital technologies as a requirement for the future of our global socio-economic growth.

Acknowledgements

This work was supported by Academy of Finland, project The Impact of Information Literacy in the Digital Workplace [grant number 295743].

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Appendix 1: Measurement instrument

Subjective Norms	SN1	Most professionals from my field use digital tools.	Taylor et al. (1995)
	SN2	Professionals that I admire use digital tools.	
	SN3	I have to use digital tools because my clients require it.	
	SN4	Professionals that use digital tools have more prestige than those who do not.	
	SN5	In my field, those who use digital tools have a high profile.	
Compatibility	CP1	Using digital tools fit well with my work routine.	Taylor et al. (1995)
	CP2	Using digital tools fit into my artistic style.	
	CP3	The setup of digital tools is compatible with my work processes.	
	CP4	Digital tools are not always compatible with the equipment that I use.	
Self-Efficacy	SE1	I feel comfortable using digital tools on my own.	Taylor et al. (1995)
	SE2	I am able to use digital tools even if there is no one to show me how to use it.	
	SE3	I am certain that I can deal with challenging tasks using digital tools.	
	SE4	I can perform effectively many different tasks by using digital tools.	
Attitude Toward Using	ATT1	The actual process of using digital tools is pleasant.	Venkatesh et al. (2003)
	ATT2	Digital tools make my work more interesting.	
	ATT3	I work better using digital tools.	
	ATT4	Digital tools enable me to be a self-directed and independent worker.	
	ATT5	Once I started working with digital tools, I find it difficult to avoid.	
Intention to Use Digital Tools	INT1	I do not hesitate to use new digital tools in my work processes.	Venkatesh et al. (2003)
	INT2	I plan to continue using digital tools in my work processes for years to come.	
	INT3	I intend to use the next versions of digital tools in my work processes.	
	INT4	I am very likely to use digital tools to create my work digitally.	
	INT5	I would recommend to other professionals in my field to use digital tools.	
Digital Literacy	**Grow up with technology**		Teo (2013) *Digital Natives Assessment Scale* (DNAS)
	DNAS1	I use the Internet for work and leisure every day.	
	DNAS2	When I need to know something, I search first online.	
	DNAS3	I keep in touch through devices with friends and online communities every day.	
	Comfortable with multitasking		
	DNAS4	I can check email and chat online at the same time.	
	DNAS5	When using the Internet for my work, I am able to listen to music as well.	
	DNAS6	I am able to use more than one application on the computer at a time.	
	Reliant on graphics for communication		
	DNAS7	I use pictures and figures more than words when I wish to explain something.	
	DNAS8	I use a lot of graphics and icons when I send messages.	
	DNAS9	I use pictures to express my feelings and ideas better.	
	Thrive on instant gratifications and rewards		
	DNAS10	I wish to be rewarded for everything I do.	
	DNAS11	I expect the websites that I regularly visit to be constantly updated.	
	DNAS12	When learning something new, I prefer to learn those that I can use quickly first.	

Applying UTAUT2 to Explain the Use of Physical Activity Logger Applications Among Young Elderly

Markus Makkonen[1,2], Tuomas Kari[1,2] & Lauri Frank[2]

[1] Institute for Advanced Management Systems Research, Turku, Finland, e-mail: markus.v.makkonen@jyu.fi, tuomas.t.kari@jyu.fi
[2] University of Jyvaskyla, Jyvaskyla, Finland, e-mail: markus.v.makkonen@jyu.fi, tuomas.t.kari@jyu.fi, lauri.frank@jyu.fi

Abstract Digital wellness technologies have been proposed as a promising way to promote the levels of physical activity and to solve the prevalent problem of physical inactivity among elderly people. In this study, we propose and test a research model for explaining the acceptance and use of these technologies in the case of the young elderly segment (people aged 60–75 years) and physical activity logger applications. The proposed model is theoretically founded on UTAUT2, and it is empirically tested by using the data collected from 115 Finnish young elderly users of a physical activity logger application and analysed with partial least squares based structural equation modelling (PLS-SEM). We find habit to act as the strongest antecedent of use intention, followed by performance expectancy and hedonic motivation with approximately equally strong effects. In contrast, the effects of effort expectancy and social influence on use intention were found as statistically not significant.

Ključne besede: physical activity logger applications, young elderly, UTAUT2, digital wellness technologies, partial least squares.

1 Introduction

In the recent years, failing to meet the recommendations for adequate amounts of physical activity has become a prevalent problem among elderly people (Sun, Norman & While, 2013). Therefore, new and innovative ways to promote the levels of physical activity in this segment are urgently needed. One potential way to achieve this are different types of digital wellness technologies, such as smartphone and smartwatch applications, which have been found very promising in terms of promoting the levels of physical activity not only among young but also among elderly people (e.g., Changizi & Kaveh, 2017; Muellmann et al., 2018; Elavsky, Knapova, Klocek & Smahel, 2019; Stockwell et al., 2019; Yerrakalva, Yerrakalva, Hajna & Griffin, 2019), although more high-quality studies especially on their long-term effects are still called for. In addition to elderly people in general, their potential has also been highlighted in the more specific segment of young elderly, which consists of people aged approximately 60–75 years (e.g., Carlsson & Walden, 2015–2019; Carlsson & Carlsson, 2016; Walden & Sell, 2017; Allmér, 2018).

However, despite their promising status as a solution for the aforementioned inactivity problem, there is a severe lack of prior studies on the antecedents of the acceptance and use of digital wellness technologies among elderly people, which can be considered a serious shortcoming in both theoretical and practical terms. The objective of the present study is to address this gap in prior research by proposing and testing a research model for explaining the phenomenon in the case of the young elderly segment and one common type of digital wellness technology: physical activity logger applications. By *physical activity logger applications*, we refer to mobile applications that enable users to log and keep track of their physical activities as well as view different types of reports about them. The data about the physical activities may be entered to the application manually by the users or it may be measured automatically by the application itself or by other applications or devices, from which it is then transferred to the application in question. The application may also act as an aggregator that extracts the data from multiple different sources. The theoretical foundation of the proposed model is based on UTAUT2 by Venkatesh, Thong, and Xu (2012). The model is empirically tested by using the data collected from 115 Finnish young elderly users of a physical activity logger application and analysed with partial least squares based structural equation modelling (PLS-SEM).

After this introductory section, we describe in more detail the research setting and the research model of the study in Sections 2 and 3. This is followed by a description of the research methodology and reporting of the research results in Sections 4 and 5. The results will be discussed in more detail in Section 6. Finally, we will conclude the paper with a brief discussion about the limitations of the study and potential paths of future research in Section 7.

2 Research Setting

This study was conducted as part of a broader research program that uses digital wellness technology to study and promote the physical activity of young elderly in Finland. The multiyear and nationwide program is conducted in close co-operation with Finnish pensioners' associations, which are responsible for recruiting volunteer participants to the program amongst their members. The interaction between the researchers and the participants takes place mainly in group meetings of about 20–50 participants, in which typically one or two researchers present the participants information about the program and collect data through surveys. The first three of these group meetings take place during the first few weeks of participation. This is followed by multiple successive self-monitoring periods of about four months, during which the participants are asked to use a physical activity logger application to collect data about their actual physical activity. At the end of each self-monitoring period, there is another group meeting. The application, like participating in the program itself, is totally free for the participants. However, all the participants are required to own a smartphone on which the application can be installed.

The application is available for both Google's Android and Apple's iOS operating systems, and it is developed by the research program itself on top of the Wellmo (2020) platform. In the group meetings, the participants are trained to use the application and instructed to conduct the logging manually by entering the type, intensity, time, and duration of their physical activities. The application also has the ability to extract the data about the physical activities automatically from other applications, such as Google Fit and Apple Health. However, in the group meetings, the participants are not trained or instructed to take this feature into use, which is why few are likely to use it. Based on the logged data, the application shows the users different types of reports about their physical activities.

3 Research Model

The research model of the study is based on UTAUT2 by Venkatesh et al. (2012), which is an extension of the unified theory of acceptance and use of technology (UTAUT) by Venkatesh, Morris, Davis, and Davis (2003) from organisational to consumer contexts. UTAUT2 has been applied to explain technology acceptance and use in numerous information systems (IS) contexts, including also the context of mobile health and fitness applications and devices (e.g., Yuan, Ma, Kanthawala & Peng, 2015; Beh, Ganesan, Iranmanesh & Foroughi, 2019; Dhiman, Arora, Dogra & Gupta, 2019; Duarte & Pinho, 2019; Talukder, Chiong, Bao & Malik, 2019) and the context of elderly users (e.g., Macedo, 2017). However, no prior studies that we are aware of have combined these two contexts by studying, for example, the acceptance and use physical activity logger applications among young elderly, as it is done in the present study.

In UTAUT2, the behavioural intention to use a particular technology is hypothesised to be positively affected by seven antecedent constructs (Venkatesh et al., 2012): *performance expectancy* (i.e., the degree to which using a technology will provide benefits to consumers in performing certain activities), *effort expectancy* (i.e., the degree of ease associated with consumers' use of technology), *social influence* (i.e., the extent to which consumers perceive that important others believe they should use a particular technology), *facilitating conditions* (i.e., consumers' perceptions of the resources and support available to perform a behaviour), *hedonic motivation* (i.e., the fun or pleasure derived from using a technology), *price value* (i.e., the consumers' cognitive trade-off between the perceived benefits of the technology and the monetary cost for using it), and *habit* (i.e., the extent to which people tend to perform behaviours automatically because of learning). In addition, UTAUT2 also introduces three moderators for the effects of these seven antecedent constructs on use intention: *age*, *gender*, and *experience*. However, because of the limited number of participants in our research program at the time of conducting the present study, these moderators are omitted in our research model. In addition, we also omit two of the seven antecedent constructs: facilitating conditions and price value. These were considered irrelevant in the current research setting because all the participants had identical resource requirements for participating in the program (i.e., owning a smartphone) and were given identical training and support for installing and using the physical activity logger application. In addition, as already mentioned above, the application

was totally free for all the participants. Finally, our research model also concentrates on explaining only use intention and not actual use behaviour. The research model, with the omitted constructs and effects presented as dashed, is illustrated in Figure 1.

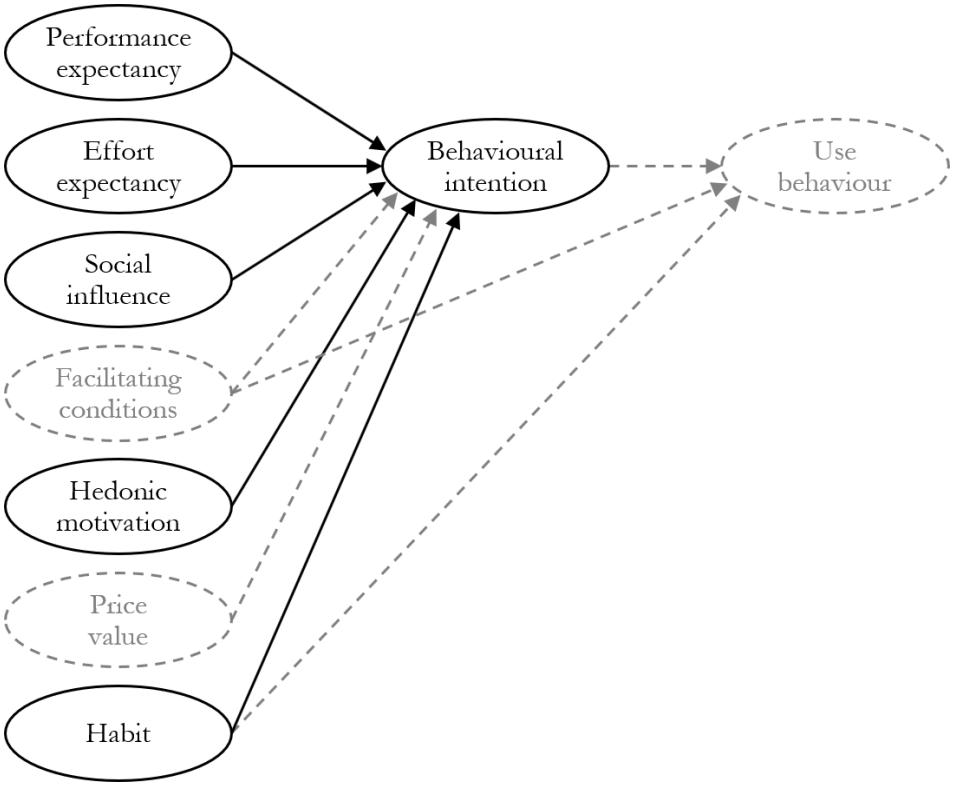

Figure 1: Research model (the dashed constructs and effects are omitted in this study)

4 Methodology

The data for the study was collected from the participants of our aforementioned research program with pen-and-paper questionnaires in the group meetings that were arranged in autumn 2019 after the first four-month self-monitoring period. Because Finland has two official languages, the participants had the option to response to the questionnaire in either Finnish or Swedish. In the questionnaire, each construct of the research model was measured reflectively by three indicators, which were all adapted from the study by Venkatesh et al. (2012). The wordings of

these indicators in English are reported in Table 1. The measurement scale of the indicators was a seven-point Likert scale ranging from one (strongly disagree) to seven (strongly agree). In addition, the participants also had the option not to respond to a particular item, which resulted in a missing value.

Table 1: Indicator wordings (PE = performance expectancy, EE = effort expectancy, SI = social influence, HM = hedonic motivation, HT = habit, BI = behavioural intention)

Indicator	Wording
PE1	I find the app useful in achieving my daily exercise goals.
PE2	Using the app helps me achieve my exercise goals more quickly.
PE3	Using the app increases my efficiency in achieving my exercise goals.
EE1	Learning how to use the app to achieve my exercise goals is easy for me.
EE2	I find using the app to achieve my exercise goals easy.
EE3	It is easy for me to become skilful at using the app to achieve my exercise goals.
SI1	People who are important to me think that I should use the app to achieve my exercise goals.
SI2	People who influence my behaviour think that I should use the app to achieve my exercise goals.
SI3	People whose opinions I value prefer that I use the app to achieve my exercise goals.
HM1	Using the app to achieve my exercise goals is fun.
HM2	Using the app to achieve my exercise goals is enjoyable.
HM3	Using the app to achieve my exercise goals is entertaining.
HT1	The use of the app to achieve my exercise goals has become a habit for me.
HT2	I am addicted to using the app to achieve my exercise goals.
HT3	I must use the app to achieve my exercise goals.
BI1	I intend to continue using the app to achieve my exercise goals.
BI2	I will always try to use the app to achieve my exercise goals.
BI3	I plan to use the app regularly to achieve my exercise goals.

Due to the relatively small sample size, the collected data was analysed with variance-based structural equation modelling (VB-SEM), more specifically partial least squares (PLS), by using the SmartPLS version 3.2.9 software by Ringle, Wende, and Becker (2015). When running the analyses and reporting the results, we followed the guidelines given by Hair, Hollingsworth, Randolph, and Chong (2017) for IS research. For example, in the model estimation, we used mode A as the indicator weighting mode of the constructs, path weighting as the weighting scheme, and +1 as the initial weights, while the statistical significance of the model estimates was tested by using bootstrapping with 2,500 subsamples and individual sign changes. As the threshold for statistical significance, we used $p < 0.05$. The potential missing values were handled by using mean replacement.

5 Results

We received valid responses from a total of 115 participants. The descriptive statistics of this sample in terms of the gender, age, and response language of the participants as well as their subjective assessment of own level of physical activity are reported in Table 2. As can be seen, nearly two-thirds of the respondents were women, and nearly nine out of ten assessed their level of physical activity as either moderate or higher. The age of the respondents ranged from 49 to 80 years, with a mean of 69.3 years and a standard deviation 5.0 years. A vast majority of the respondents belonged to the young elderly segment, but there were also a few respondents who were slightly younger or older than our target segment consisting of people aged approximately 60–75 years. However, we decided not to drop these respondents from the study due to our relatively small sample size.

Table 2: Sample statistics (N = 115)

	N	**%**
Gender		
Man	43	37.4
Woman	72	62.6
Age		
Under 60 years	3	2.6
60–64 years	11	9.6
65–69 years	44	38.3
70–74 years	39	33.9
75 years or over	18	15.7
Language		
Finnsh	69	60.0
Swedish	46	40.0
Level of physical activity		
Very high	1	0.9
High	18	15.7
Moderate	84	73.0
Low	4	3.5
Very low	8	7.0
Totally passive	0	0.0

5.1 Estimation Results

Estimation results of the model in terms of the size and statistical significance of the standardised path coefficients as well as the proportion of explained variance in the behavioural intention construct are reported in Figure 2. Of the five antecedent constructs, performance expectancy, hedonic motivation, and habit were found to have a positive and statistically significant effect on behavioural intention, whereas the effects of effort expectancy and social influence were found to be statistically not significant. Together, the five antecedent constructs were found to explain about 73.5% of the variance in behavioural intention.

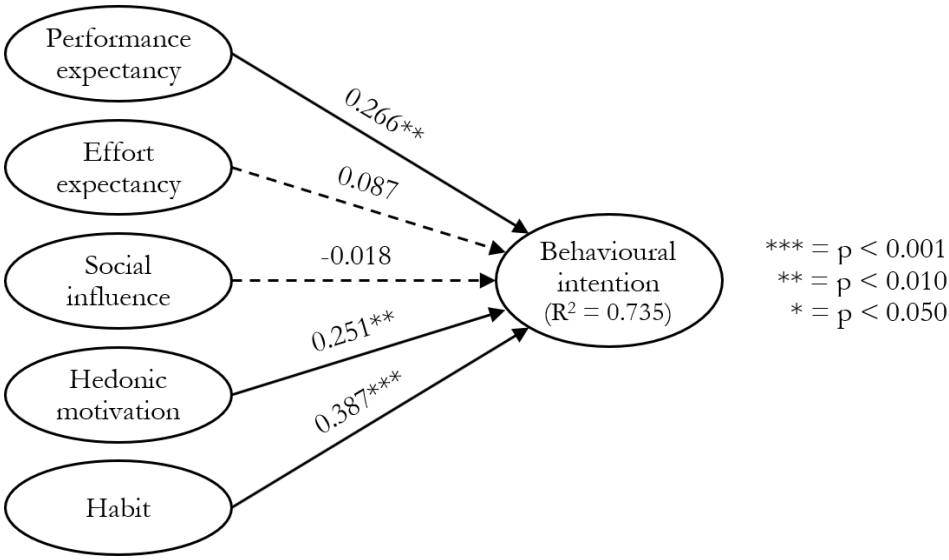

Figure 2: Estimation results

In the following two subsections, the reliability and validity of the estimated model is examined in more detail at the level of both constructs and indicators.

5.2 Construct Reliability and Validity

Construct reliabilities were evaluated by using the composite reliabilities (CR) of the constructs (Fornell & Larcker, 1981), which are commonly expected to be greater than or equal to 0.7 (Nunnally & Bernstein, 1994). The CR of each construct is reported in the first column of Table 3. As the reported values show, all the constructs met this criterion. In turn, construct validities were evaluated by examining the convergent and discriminant validities of the constructs by using the two criteria proposed by Fornell and Larcker (1981). Both of them are based on the average variance extracted (AVE) of the constructs, which refers to the average proportion of variance that a construct explains in its indicators.

Table 3: Construct statistics (CR = composite reliability, AVE = average variance extracted)

Construct	CR	AVE	PE	EE	SI	HM	HT	BI
PE	0.906	0.763	0.873					
EE	0.849	0.654	0.426	0.809				
SI	0.923	0.800	0.548	0.250	0.894			
HM	0.927	0.809	0.680	0.448	0.495	0.900		
HT	0.849	0.653	0.719	0.479	0.466	0.772	0.808	
BI	0.928	0.812	0.743	0.494	0.454	0.761	0.806	0.901

In order to exhibit satisfactory convergent validity, the first criterion expects that each construct should have an AVE of at least 0.5. This means that, on average, each construct should explain at least half of the variance in its indicators. The AVE of each construct is reported in the second column of Table 3. As the reported values show, all the constructs met also this criterion. In order to exhibit satisfactory discriminant validity, the second criterion expects that each construct should have a square root of AVE greater than or equal to its absolute correlation with the other constructs in the model. This means that, on average, each construct should share at least an equal proportion of variance with its indicators than it shares with these other constructs. The square root of AVE of each construct (on-diagonal cells) and the correlations between the constructs (off-diagonal cells) are reported in the remaining columns of Table 3, showing that this final criterion was also met by all the constructs.

5.3 Indicator Reliability and Validity

Indicator reliabilities and validities were evaluated by using the standardised loadings of the indicators, which are reported in Table 4 together with the mean and standard deviation of each indicator as well as the percentage of missing values. In the typical case where each indicator loads on only one construct, it is commonly expected that the standardised loading of each indicator is statistically significant and greater than or equal to 0.707 (Fornell & Larcker, 1981). This is equal to the standardised residual of each indicator being less than or equal to 0.5, meaning that at least half of the variance in each indicator is explained by the construct on which it loads. The only indicator that did not meet this criterion was EE3. However, also its standardised loading of 0.688 was very close to the 0.707 threshold and clearly above the 0.4 threshold, which has been proposed in some prior guidelines for IS research (e.g., Gefen, Straub & Boudreau, 2000). Therefore, and because no issues were found in the reliability and validity of the effort expectancy construct, we decided not to drop this indicator from the model.

Table 4: Indicator statistics (SD = standard deviation, *** = p < 0.001)

Indicator	Mean	SD	Missing	Loading
PE1	5.468	1.619	5.2%	0.889***
PE2	5.020	1.761	12.2%	0.866***
PE3	5.083	1.658	6.1%	0.865***
EE1	6.195	1.301	1.7%	0.849***
EE2	6.027	1.268	3.5%	0.876***
EE3	5.640	1.488	3.5%	0.688***
SI1	4.135	2.196	22.6%	0.933***
SI2	4.476	2.127	28.7%	0.923***
SI3	5.202	1.841	22.6%	0.824***
HM1	5.566	1.324	7.8%	0.906***
HM2	5.660	1.310	10.4%	0.883***
HM3	4.892	1.723	11.3%	0.911***
HT1	5.879	1.558	7.0%	0.828***
HT2	4.029	2.041	10.4%	0.730***
HT3	4.848	1.920	8.7%	0.860***
BI1	5.569	1.755	11.3%	0.906***
BI2	5.214	1.696	10.4%	0.868***
BI3	5.570	1.677	7.0%	0.928***

6 Conclusions

In this study, we proposed and tested a research model based on UTAUT2 for explaining the use intention of physical activity logger applications among young elderly. Despite omitting some of the constructs and moderators of the original UTAUT2, we found the model to explain as much as about 73.5% of the variance in use intention. More specifically, its estimation results suggested three main findings. First, by far the strongest antecedent of the intention to use physical activity logger applications among young elderly seemed to be habit. Second, based on the statistically significant and approximately equally strong effects of performance expectancy and hedonic motivation on use intention, it seemed that the motivation to use physical activity logger applications among young elderly was driven by both utilitarian and hedonic considerations about their use. Third, based on the statistically not significant effects of effort expectancy and social influence on use

intention, it seemed that the perceived ease of use of physical activity logger applications or the perceived opinions of important others about their use were not that relevant for young elderly in terms of their use motivation.

From a theoretical perspective, when reflecting the aforementioned findings to the hypotheses of UTAUT2, the first finding concerning the effect of habit cannot be considered as particularly surprising because habit is hypothesised to have a stronger effect on behavioural intention in the case of older people, whereas the effects of performance expectancy and hedonic motivation on behavioural intention are hypothesised to be stronger in the case of younger people. In contrast, the third finding concerning the effects of effort expectancy and social influence can be seen as more surprising when considering that UTAUT2 hypothesises that the effects of effort expectancy and social influence on behavioural intention should also be stronger in the case of older people, particularly older women who constituted the majority of our study sample. In turn, when reflecting our findings to those of prior studies that have applied UTAUT2 to the context of mobile health and fitness applications and devices (e.g., Yuan et al., 2015; Beh et al., 2019; Dhiman et al., 2019; Duarte & Pinho, 2019; Talukder et al., 2019) as well as to the context of elderly users (e.g., Macedo, 2017), the most important and interesting conflict concerns the relative strengths of performance expectancy, hedonic motivation, and habit as antecedents of use intention. That is, prior studies (e.g., Yuan et al., 2015; Macedo, 2017; Duarte & Pinho, 2019) have typically found performance expectancy to act as clearly the strongest antecedent of use intention, whereas hedonic motivation and habit have typically been found to have approximately equally strong but weaker effects. In contrast, in our study, the roles of performance expectancy and habit seem to have been swapped, with habit acting as clearly the strongest antecedent of use intention and performance expectancy and hedonic motivation having approximately equally strong effects. The main exception to this is the study by Talukder et al. (2019), which also found habit to have the strongest effect on the use intention of wearable fitness devices. However, in their study, performance expectancy was found to have an approximately equally strong effect as habit, whereas hedonic motivation was found to have no statistically significant effect on use intention. Finally, in terms of the statistically not significant effects of effort expectancy and social influence found in our study, some prior studies have made similar findings (e.g., Yuan et al., 2015; Duarte & Pinho, 2019), whereas others have found the effect of either effort expectancy (Macedo, 2017; Beh et al., 2019) or both

effort expectancy and social influence (Dhiman et al., 2019; Talukder et al., 2019) as statistically significant, although in most cases as relatively weak.

From a practical perspective, the findings of the study offer the providers of physical activity logger applications, and potentially also the providers of other types of digital wellness technologies that are targeted at promoting the physical activity of young elderly, some valuable insights on technology acceptance and use. First, it is critical that the potential users can easily integrate the applications as part of their everyday practices and make their use habitual. If the use becomes habitual, then it is very likely to continue also in the future. Second, it is not enough for the providers to develop their applications with only utility and performance aspects in mind, but the applications should also be fun to use. Two examples of the approaches that can be used to achieve this goal are gamification (e.g., Kari, Piippo, Frank, Makkonen & Moilanen, 2016; Koivisto & Hamari, 2019) and exergaming (e.g., Kari, 2014; Kari & Makkonen, 2014; Kappen, Mirza-Babaei & Nacke, 2019). Third, although we did not find effort expectancy and social influence to directly affect use intention, these two factors may still affect it indirectly via so-called crossover effects (Taylor & Todd, 1995). This is why their role should not be entirely ignored. For example, as hypothesised in the technology acceptance model (TAM) by Davis (1989), technologies that are perceived as easier to use are also typically perceived as more useful, suggesting a link between effort expectancy and performance expectancy. A similar link may also exist between effort expectancy and habit because use behaviour can be assumed to become habitual more easily in the case of technologies that are perceived as easy to use.

7 Limitations and Future Research

This study can be considered to have four main limitations. First, the study concentrated on only one particular type of digital wellness technology for promoting the physical activity among young elderly: physical activity logger applications. This obviously limits the generalisability of its findings in terms of other digital wellness technologies. Second, the research setting of the study does not fully correspond to the real-life market environment in which consumers make decisions on technology acceptance and use. For example, the participants were provided for free with both the application as well as the training and support for installing and using it. Without these, factors such as facilitating conditions and price value, which

were omitted in the research model of the study, may also play an important part as antecedents of use intention and use behaviour. Third, the research model of the study concentrated only on use intention and not on actual use behaviour. Although the link between use intention and use behaviour is hypothesised in theories like the aforementioned TAM, UTAUT, and UTAUT2, future studies should also aim at empirically verifying it by incorporating the use behaviour construct into their research models and collecting data on actual use. This is already part of our future plans. In our future studies, when we are able to recruit more participants to our research program, we are also planning to increase our sample size, which will allow, for example, the examination of more complex interaction effects between the constructs of our research model.

Acknowledgements

We would like to thank Professors Christer Carlsson and Pirkko Walden from the Institute for Advanced Management Systems Research for their insightful feedback.

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THE OMITTED VARIABLE: COULD DUOTEST ENABLE A NEW WAY TO ASSESS TEAM PERFORMANCE IN TEAM-BASED LEARNING?

RICCARDO BONAZZI[1]& YVIANE ROUILLER[2]

[1] University of Applied Sciences and Arts Western Switzerland (HES-SO), Institute of Entrepreneurship and Management , Sierre, Switzerland, e-mail: riccardo.bonazzi@hevs.ch
[2] Haute Ecole Pédagogique du Valais, St-Maurice, Switzerland, e-mail: yviane.rouiller@hepvs.ch

Abstract This article is part of an ongoing project to develop a method for team-based learning named Testudo. We present an assessment technique called DuoTest, which allows students to do their final exam twice in a row: the first time, participants do their exam individually (Exa01); the second time, they solve the same exam in groups (Exa02). By comparing individual and group exams, the system induces the positive (or negative) effect of each team over the individual performances. Empirical results collected from 70 students show that individual exams are a reliable, although weak, predictor of the group scores ($p<0.10$, Adj $R2= 0.02$). Instead, by measuring the fixed effect of each team, we obtain a better predictor of Exa02 (Adj $R2= 0.71$). Although additional testing is required, our guidelines address a current gap in the literature for techniques that rigorously assess the individual and team dimensions, and that are easy to implement.

Ključne besede: team-based learning, project-based learning, team assessment, individual assessment, immediate feedback assessment technique, design science research.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.39
ISBN 978-961-286-362-3

1 Introduction

> *"The town had a low wall of no great extent on one side, and to attack this the Romans employed three picked maniples. [...] The men of the first held their shields over their heads, and closed up, so that, owing to the density of the bucklers, it became like a tiled roof [...] in the shape of a tortoise (testudo)".*
> *Polybius, The Histories – Book 28.11*

The Roman Testudo is a well-known example of a military formation, where soldiers put together their shields to achieve a common goal, such as to protect themselves against a threat or to let other soldiers walk upon it whenever they come to a narrow ravine. Nonetheless, such powerful feature came at a price, since Roman Testudo were said to be advancing slowly in combat, since soldiers had to coordinate themselves. Accordingly, the Roman Testudo and its trade-off could be used as a metaphor for a situation, where students are expected to work together and solve a problem as a team.

There are still mixed evidences on whether working in teams is an appropriate method to prepare students for the challenges of a constantly changing business environment: on the one hand, some teachers prefer to give instruction via teacher-centered methods (lectures with little text reading and student discourse), under the belief that the best way to ensure content learning is for the instructor to present all necessary information to students (McKeachie and Svinicki, 2013). On the other hand, some scholars claim that traditional teaching methods do not enable all students to appropriately engage with the types of academic literacy constitutive to higher education (Hake, 1998; Lea and Street, 2006). Hence, this article starts with a simple intuition to bridge the two viewpoints: if we assume that the team itself is an important outcome of a team project, could we assess, at the end of the course, if the students would have been more/less effective without it? Indeed, there is a consensus on the difficulty of correctly assessing the performance of each student in a team project (Brazhkin & Zimmerman, 2019), and most educators lack a simple tool to do it. Nonetheless, most of the previous works have considered the team as noise to be cancelled to assess the individual, whereas we consider it as the most important artefact of a course, which asks students to work in teams to solve real-world projects and reflect on what they learned by doing so.

According to Kolb (2015) *learning* is the process whereby knowledge is created through the transformation of experience. *Group-based learning* is seen as a form of experiential learning and it has been termed differently through the years: (a) *small group learning* (Springer et al., 1999) include activities where the teacher lectures for 15–20 minutes and then asks students to pair with the student beside them to discuss a question, (b) *collaborative learning* involves carefully planned and structured group activities that are infused into a course of learning, whereas (c) *Team-based learning (TBL)* makes intense use of small groups in that it changes the structure of the course, in order to develop and then take advantage of the special capabilities of high-performance learning teams (Michaelsen et al., 2004). According to its authors, TBL is an important opportunity for teamwork skill development, experiential learning, and learning from peers. However, TBL presents many challenges and is most appropriate in courses that meet two conditions: (1) students are required during the course to understand a significant body of information and (2) a primary goal of the course is to apply this content by solving problems, answering complex questions and resolving issues (Swanson et al., 2019).

Accordingly, our research question is: **"how can we design a summative assessment of individual and team performance in a team-based learning scenario?"**

The rest of the paper proceeds as it follows. Section 2 briefly reviews the existing body of knowledge to answer our research question. Section 3 describes design science as our chosen methodology, highlights the relevant elements of the course which applies the Testudo method and then describes how to create and test the DuoTest prototype. Section 4 presents our preliminary findings, whereas section 5 concludes the paper by discussing the contribution and shortcomings of our work.

2 Literature review

In this section, we briefly assess the existing body of knowledge and define three constructs to avoid the *jingle fallacy* (constructs with the same name referring to different phenomena): (a) *team health*, which can be used to assess how well individuals work together in a team, (b) *transactivity*, to assess how each individual in a team can build on previous works from team members and (c) *immediate feedback*

assessment technique, a tool used for summative evaluation in team-based learning that could be used to assess transactivity.

2.1 I2T: Individual contributions for the Team health

Recent work from (O'Neill et al., 2020) presents a set of 18 questions to rapidly and reliably assess the *team health* by asking team members to describe their perception of team communication, adaptability, relationships and education. Other scholars have suggested that assessment in TBL should take into account the cognitive, affective and behavioral dimensions (Brazhkin & Zimmerman, 2019). Indeed, students have multiple goals and motivations, which influence the team performance: mastery goals ("I want to learn new things") and social responsibility goals ("I want help my peers") prevail in effective teams, whereas belongingness goals (e.g., "I want my peers to like me") were more important than mastery goals in ineffective teams (Hijzen et al., 2007).

2.2 T2I: Team effect on the Individual performance

To some degree, the *group product* will be codified in an artifact (e.g., group report, dialogue, diagram, etc.), but the individual experience of that collaborative learning event will be transposed to future collaborative learning events. (Strijbos, 2010). Accordingly, the team effect can be associated to *transactivity*, that is the extent to which students refer and build on each other's' contributions and it can be measured by reflected in collaborative dialogue or individual products, or the extent to which students transform a shared artifact (e.g., a group report) (Weinberger et al., 2007).

2.3 Gap in the literature: how to assess transactivity

The *immediate feedback assessment technique* (IF-AT) form has (a) a series of boxes covered by an opaque, waxy coating similar to that found on scratch-off lottery tickets corresponding to the alternatives, with only one correct alternative having with a small star in it (Maurer & Kropp, 2015). The athours found that students who did the final exam with the Immediate Feedback Assessment Technique (IF-AT) scored 10% more on average when they got partial credit for iterative responding (they could scratch more then one box). Although, this approach is already used in

team-based learning scenarios (Mazur, 1999), there is not a simple way to use it and assess how team transactivity influence individual performance.

3 Chosen methodology to develop and test the artefact

We position our study in the field of design science research (Hevner et al., 2004) and we developed an artefact in the shape of a prototype (March & Smith, 1995), following the guidelines of Peffers et al. (2007).

Identify problem and motivate. We describe an example of course of organization design, which would like to assess transactivity. At the beginning of the semester, students play a multi-round business simulation game (Martin-Rios & Erhardt, 2019). In this phase, students are assigned to a new random group every week, to learn how to rapidly work together and take decision under uncertainty. After four weeks, students form a group of max 5 team members. In this phase, students are assigned to a real project done with an external firm for eight weeks. All projects respect the five criteria for a project-based learning activity (Thomas, 2000): (a) projects are central to the curriculum, since the score given to the students reports will count as their midterm exam, (b) they are focused on problems that 'drive' students to encounter/struggle with the central concepts of a discipline, (c) they involve students in a constructive investigation, since students have to help the firm make sense of its data to find the solution, (d) they are student-driven to a significant degree, and (e) they are realistic and not school-like. Every week, students are asked to fill in a new section of the report and to submit it on a Moodle Workshop activity (Moodle, 2019a), where it will be assessed by their peers. During each class, the teacher briefly clarifies the required activities and facilitates discussions among team members. Slides are seldomly presented in class, since they are available to students in advance, together with check-up questions, as Moodle Lessons (Moodle, 2019b).

Define objectives of the solution. We wanted to improve the immediate feedback assessment technique (IF-AT) by developing an online solution, which could allow students to do the final exame by themselves and then to get partial credits if they managed to correct their mistakes, by discussing with their team members. This way, we could measure the degree of transactivity in each team. Accordingly, we state three hypotheses, which we would like to test:

- H1: the individual performance of Exa01 has a positive and statistically significant effect over the individual performance of Exa02. This statement is supported by all the reviewed literature on team-based learning
- H2: the team performance (*transactivity*) has a statistically significant effect over the individual performance of Exa02. If this hypothesis is correct, we should be able to see different improvement in different teams, depending on their degree of transactivity
- H3: the team performance has positive and statistically significant effect over the indivdual performance of Exa02. H3 extends H2. Based on previous results from (Maurer & Kropp, 2015) on IF-AT with partial credit, we could assume that a student having the possibility to correct his mistakes by discussing with his team will improve his final score.

Design and development of the artefact: the DuoTest prototype. The underlying idea of DuoTest is simple: to allow students to do their final exams twice in a row: the first time, participants do their exam individually (Exa01); the second time, they solve the same exam in groups (Exa02). By comparing individual and team performances, the system induces the positive (or negative) effect of each group over the individual performances.

Demonstration. Before the exam, we create a Moodle Quiz activity (Moodle, 2019) with ten questions: five theoretical questions and five questions about a case study. The type of the ten questions is Short Answer (Moodle, 2020): this will be relevant when we explain how to analyze the data after the exam. In the parameters of the Moodle Quiz activity, hereinafter referred to as Exa01, we set the duration at 35 minutes. Then, we copy the Quiz activity a second time, hereinafter referred to as Exa02. This way, the questions of Exa02 are the same of Exa01. In the parameters of Exa02, we set the beginning of the activity 5 minutes after the end of Exa01, to allow students the logistical time to setup their teams in the class. The duration of Exa02 is set at 20 minutes, which brings the total to 60 minutes. Finally, in the Moodle Gradebook (Moodle, 2019), we set the score of the final exam as the average between Exa01 and Exa02.

During the exam, students are expected to do Exa01 without additional material and by themselves. When Exa01 is over after 35 minutes, each student assembles with the team members, with whom he has been working between week 5 and 12.

Students can talk among them during Exa02 and they have access of any type of material. Indeed, Exa02 recreates the conditions that the team has lived during the semester and allows educators to assess in detail the dynamics of each team.

After the test, each answer is corrected by using a special feature of Short-answer questions: the educator defines a set of rules in the parameters of each question, and the answers of all students are corrected automatically by Moodle. This assures a coherent assessment all along and it increases the rigor of the overall process.

Evaluation. We tested our prototype with three classes of undergraduate students undertaking the same course, for a total of 71 students attending the final exam in Sierre (Switzerland) the 20th of January 2020. We claim that the exam was (a) valid, since chosen questions provide useful information about the concepts seen in class, (b) reliable, thanks to the rule-driven correction of each question, and (c) recognizable, since it fully replicated the way students work during the semester.

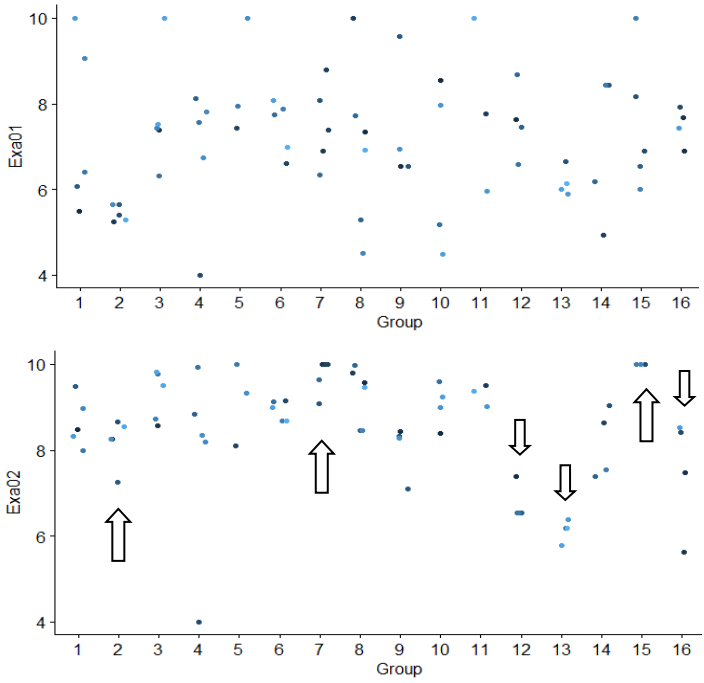

Figure 1: Students scores in the individual exam (Exa01) and group exam (Exa02)

4 Preliminary findings

This section analyses the results of the individual and the group exams, which are shown in Figure 1. One could expect the results of the second exam to be better than the first one, such as in the case of group G02, which had a strong concentration of scores below 6/10 and shifted up above 8/10. Some team performed better than other, with team G15 bringing all team members up to 10/10 and group G07 bringing a dispersed set of points in the first exam up above 9/10 in the second exam. Nonetheless, some teams performed worse in the second exam, the groups G12 and G13 being the most evident example of individuals, who decided to change some correct answers into wrong answers after discussing with the rest of the team. Finally, Group G04 had a student who attended the exam, but did not do it (row 18 in the table of Appendix A). To assign some quantitative data to our assessment, with start by scaling the raw data presented in Appendix A, in order to properly compare the coefficients of each variables. Moreover, after having looked for outliers with a large residual, we identify and remove the outlier in the

row 18. Table 1 illustrates that the performance of the first exam (*Exa01*) positively effects the score of the second exam (*Exa02*), with a coefficient of 0.20 (hence *Exa02 = 0.20*Exa01*). The value of p = 0.09 shows that the relationship between the two variables is statistically significant. Therefore, ***we confirm the hypothesis H1***, and affirms that there is a causal effect between the first exam (done individually) and the second exam (done in group). Nonetheless, the Adjusted R2 = 0.03 suggests that the explanatory power of this model is fairly low. Hence, we add 15 binary variables for the 16 groups (the first group G01 will have 0 for each group variable). The Adjusted R2 of the new model is very good (0.71) and the coefficient of the first Exam (0.06) is not statistically significant anymore (p = 0.41), leading us to ***confirm the hypothesis H2***, which states that the team effect increases the explanatory power of our model.

Indeed, one could assume that the increase in the value of the R2 would be the consequence of using more variables; but the Adjusted R2 automatically adjusts the R2 of the model to take this effect into account. Moreover, the regression diagnostics in Appendix B does not indicate any further issues. Nonetheless, the analysis of the coefficients shows that ***we cannot confirm nor reject hypothesis H3***, which state that the team has a positive effect on the individual performance. The quantitative analysis rejoins the insights already visible from Figure 1: the coefficient of some groups (e.g. G07 and G15) is greater than the one of Exa01, whereas some other groups have a negative coefficient (G12 G13 and G16).

Table 1: Exa02 as a function of individual exam(model 01) and team *transactivity* (model 02)

Variable	Model 01: Individual	Model 02: Group Effect
Intercept	0.00 (1.00)	0.02 (0.92)
Exa01	0.20 (0.09)	0.06 (0.41)
Group 02		-0.31 (0.39)
Group 03		0.53 (0.13)
Group 04		0.15 (0.69)
Group 05		0.38 (0.35)
Group 06		0.24 (0.49)
Group 07		**0.94 (0.01)**
Group 08		0.57 (0.09)
Group 09		-0.53 (0.15)
Group 10		0.39 (0.30)
Group 11		0.54 (0.18)
Group 12		**-1.65 (0.00)**
Group 13		**-2.12 (0.00)**
Group 14		-0.41 (0.26)
Group 15		**1.16 (0.00)**
Group 16		**-0.99 (0.01)**
Adjusted R2 of the model	*0.03*	*0.71*

A final remark should be done for G02, and its surprising negative coefficient. Figure 1 shows that the score Exa02 of everyone increased from Exa01. Nonetheless, the quantitative analysis shows that students of group G02, who got the best Exa01 results, are those who got the worse Exa02 results afterwards.

5 Discussions and conclusions

This article started by using the metaphor of the Roman Testudo to describe how students learn to cooperate in order to deal with problems in their future careers. Our study suggests that what seems to be a single phenomenon (*team performance*) is in reality composed of assorted heterogeneous elements (Davis, 1971): *team health*, which depends on each team member, and *transactivity*, which influences the future performance of each team member and that we called "the omitted variable" in the title of the article. Accordingly, we wanted to look for new ways to design a final exam to assess individual and team performance in a team-based learning (TBL) course. Such objective is relevant and persisting in the field of study of information systems, since TBL is increasingly used to teach university students how to work

together and solve complex problems in a growing number of fields, and we were missing of a structured and simple way to perform summative assessment. Although our approach might be biased towards TBL as a form of teaching, our intent is to bridge forms of experiential learning with classic testing techniques such as written exams. We have selected and reviewed previous works from the fields of team-based learning, project-based learning and software solution to assess students. Although such works are complementary, a paper that combines these three views to develop an artefact is missing. Therefore, we have decided to create a theory of design and action (Gregor, 2006), which explains how to do something and gives explicit prescriptions for teachers to construct a new type of final test for TBL classes, which we called DuoTest. Our preliminary findings show promising results that needs to be replicated in other classes and other topics. So far, DuoTest extends existing solutions for immediate impact assessments (Maurer & Kropp, 2015), since it allows to obtain deeper insights on the effect of the team on the individual performance and on the effect of such individuals on the team, at a fraction of its cost. Nonetheless, future work should try to categorize the different types of transactivity performance, and to explain how to predict the coefficients of each team by using data collected during the semester to link together *team health* and *transactivity*.

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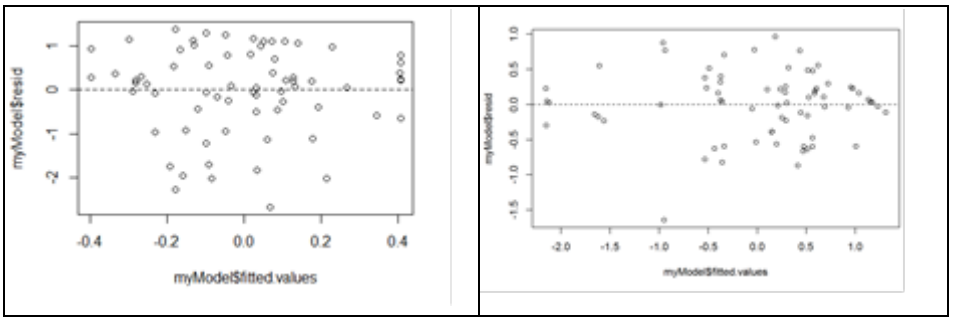
Appendix A: Complete dataset with the raw data

UID	Group	Class	Exa01	Exa02
1	1.00	2.00	5.50	8.48
2	10.00	3.00	8.54	8.39
3	8.00	1.00	7.34	9.57
4	12.00	3.00	7.64	7.39
5	16.00	3.00	6.89	7.47
6	9.00	3.00	6.54	8.44
7	3.00	1.00	7.39	8.57
8	16.00	3.00	7.69	5.62
9	7.00	2.00	6.90	10.00
10	2.00	1.00	5.25	8.25
11	11.00	3.00	7.77	9.52
12	8.00	1.00	10.00	9.79
13	7.00	2.00	8.79	10.00
14	14.00	2.00	4.94	8.64
15	7.00	2.00	7.39	10.00
16	5.00	2.00	7.44	8.09
17	6.00	3.00	6.60	9.14
18	4.00	2.00	4.00	4.00
19	16.00	3.00	7.92	8.42
20	15.00	3.00	6.89	10.00
21	2.00	1.00	5.40	8.65
22	13.00	1.00	6.64	6.19
23	15.00	3.00	8.18	10.00
24	14.00	2.00	8.43	9.04
25	7.00	2.00	8.09	9.09
26	9.00	3.00	6.55	7.10
27	9.00	3.00	9.58	8.34
28	2.00	1.00	5.65	7.25
29	1.00	2.00	6.08	9.48
30	15.00	3.00	6.55	10.00
31	12.00	3.00	7.45	6.54
32	4.00	2.00	8.12	8.84
33	8.00	1.00	5.29	8.47
34	14.00	2.00	6.19	7.39
35	8.00	1.00	7.72	9.97
36	12.00	3.00	8.69	6.54
37	7.00	2.00	6.34	9.64
38	6.00	3.00	7.74	9.14
39	10.00	3.00	5.18	9.59
40	3.00	1.00	6.32	9.77
41	4.00	2.00	7.57	9.94
42	12.00	3.00	6.59	6.54
43	1.00	2.00	6.40	7.98
44	5.00	2.00	7.95	10.00
45	14.00	2.00	8.44	7.54
46	6.00	3.00	7.88	8.69
47	15.00	3.00	10.00	10.00
48	3.00	1.00	7.43	8.72
49	15.00	3.00	6.00	10.00
50	8.00	1.00	4.50	8.47
51	1.00	2.00	9.05	8.98
52	4.00	2.00	7.82	8.19
53	2.00	1.00	5.65	8.25
54	5.00	2.00	10.00	9.34
55	4.00	2.00	6.74	8.34
56	9.00	3.00	6.95	8.29
57	10.00	3.00	7.97	8.99
58	11.00	3.00	5.97	9.02
59	13.00	1.00	5.90	6.39
60	1.00	2.00	10.00	8.33
61	16.00	3.00	7.44	8.52
62	10.00	3.00	4.50	9.24
63	6.00	3.00	8.09	8.99
64	13.00	1.00	6.00	5.79
65	3.00	1.00	7.52	9.82

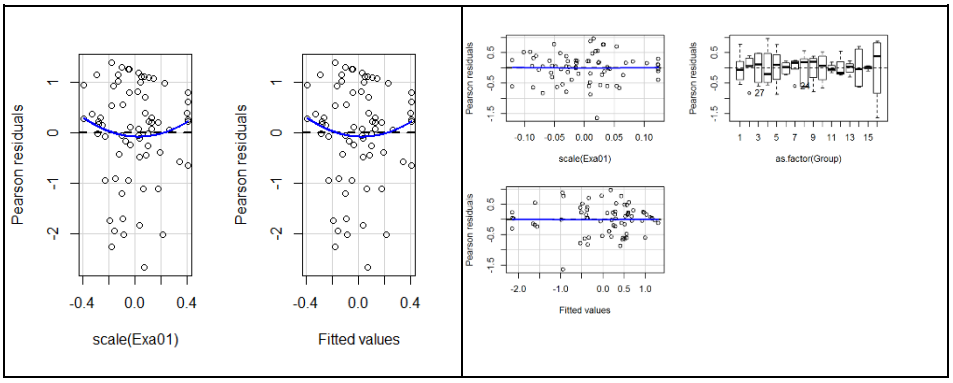
66	3.00	1.00	9.99	9.52
67	2.00	1.00	5.30	8.55
68	11.00	3.00	10.00	9.37
69	8.00	1.00	6.92	9.47
70	6.00	3.00	6.99	8.69
71	13.00	1.00	6.14	6.19

Appendix B: Regression diagnostic for model 01 (left) and model 02 (right)

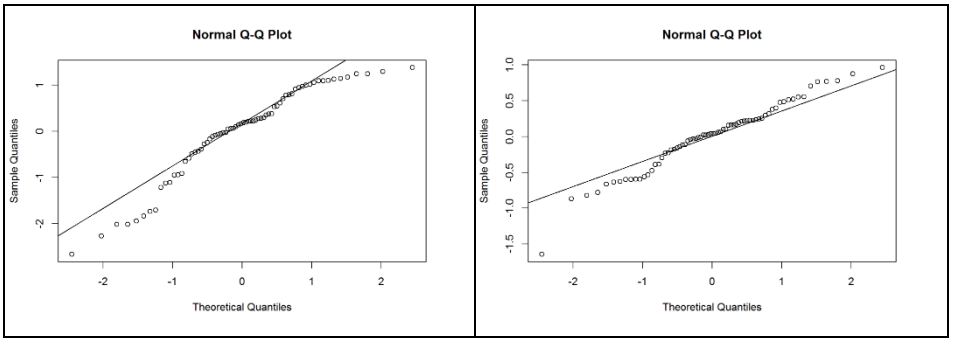
Homogeneity of variance: The error variance seems constant in the two models



Linearity: the relationships predictors and Exam02 becomes linear in model 02



Normality: the errors are normally distributed; hypotheses testing is reliable



Multicollinearity: when VIF > 10 a variable merits further investigation

	VIF	Df	GVIF^(1/(2*Df))
scale(Exa01)	1.32	1	1.15
as.factor(Group)	1.32	15	1.01

DATA SERVICE CARDS - A SUPPORTING TOOL FOR DATA-DRIVEN BUSINESS

GERT BREITFUSS[1], MICHAEL FRUHWIRTH[1], CHRISTOF WOLF-BRENNER[1], ANGELIKA RIEDL[1], MARK DE REUVER[2], ROBERT GINTHOER[1] & OLIVER PIMAS[1]

[1] Know-Center, Graz, Austria, e-mail: gbreitfuss@know-center.at, mfruhwirth@know-center.at, cbrenner@know-center.at, ariedl@know-center.at, rginthoer@know-center.at, opimas@know-center.at
[2] Delft University of Technology, Delft, Netherlands, email: g.a.dereuver@tudelft.nl

Abstract In the future, every successful company must have a clear idea of what data means to it. The necessary transformation to a data-driven company places high demands on companies and challenges management, organization and individual employees. In order to generate concrete added value from data, the collaboration of different disciplines e.g. data scientists, domain experts and business people is necessary. So far few tools are available which facilitate the creativity and co-creation process amongst teams with different backgrounds. The goal of this paper is to design and develop a hands-on and easy to use card-based tool for the generation of data service ideas that supports the required interdisciplinary cooperation. By using a Design Science Research approach we analysed 122 data service ideas and developed an innovation tool consisting of 38 cards. The first evaluation results show that the developed Data Service Cards are both perceived as helpful and easy to use.

Keywords: data driven business, card-based tools, data service development, business model innovation, design science research.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.40
ISBN 978-961-286-362-3

1 Introduction

Companies that manage to create added value from existing or newly acquired data secure an important competitive advantage. But the necessary transformation to a data-driven company places high demands on companies and challenges management, organization and individual employees.

Whether customer data, measurement data, real-time data from sensors, analysis data, monitoring and log data from IT systems, data from existing data warehouse solutions or even external data from social networks, the Internet or business partners, all this is available and can be used today. Thanks to enabling technologies (e.g. anonymization, privacy-preservation) more and more data is becoming available for businesses to use, which leads to the question how they can now use those data in ways that benefit their business model. In order to generate concrete added value from data, the knowledge of how a data-driven service is developed must be built up in the company. As Bertoncello et al. (2018) stated, a lack of structured value proposition design and a limited understanding of customer benefits are challenges in developing data-driven services. Another challenge is the necessary collaboration of different disciplines e.g. data scientists, domain experts and business people. There are already several tools and methods supporting the development of new data-driven business, ranging from general tools like the Business Model Canvas (Osterwalder, 2010) to data specific tools e.g. the Data Canvas (Mathis & Koelber, 2016) or the Data Innovation Board (Kronsbein & Mueller, 2019). Although much research has been done, there is limited knowledge on how to facilitate creativity and co-creation amongst people with different backgrounds in the development process of data-driven product/service ideas.

Therefore, our main research objective is to design and develop a hands-on and easy to use tool (Data Service Cards) for the generation of data products/service ideas that supports the required interdisciplinary cooperation between (data) experts and non-data experts. The newly developed Data Service Cards (DSC) aims to bridge the gap between disciplines and backgrounds (IT, data science, business development, sales, etc.) The tool should engage the collaborative teamwork and help to innovate existing or new data-driven business opportunities. Specifically, we seek to answer the following research questions:

RQ: How should a haptic tool (cards) for developing a data-driven product/service idea be designed to support the co-creation process of innovation teams with different backgrounds and levels of expertise?

The paper is structured as follows: Section 2 provides the theoretical framework regarding data-driven business and cards as an innovation facilitation tool. Section 3 outlines the applied design science research method. The following chapter 4 is describing the research results, beginning with the categorization and followed by the design of the Data Service Cards. Subsequently, insights from a first evaluation will be presented in chapter 5. Finally, chapter 6 summarizes and discusses the results and provides an outlook on further research.

2 Background

2.1 Data-driven Services

Data and analytics hold the potential also for traditional organizations for service innovation (Engel and Ebel, 2019). Data and analytics can be used to improve internal processes and decision making (Wixom and Ross, 2017), to enrich existing products or services with data (Davenport, 2013) or even to create new data-driven services and business models (Hartmann et al., 2016). In data-driven services, data and analytics are used "to support the decision-making process of the customer via data and analytics-based features and experiences in form of a stand-alone offering or bundled with an existing product or service" (Schüritz et al., 2019). Despite the potential for business growth (Seiberth and Gründinger, 2018) it is very challenging for traditional organizations to innovate new services and business models based on data and analytics (Schüritz et al., 2017; Fruhwirth et al., 2018). There is a lack of data-focused innovation tools and methods support that process <<masked for peer-review>>. Further, there is very little knowledge available on how organizations could get started (Agrawal et al., 2018).

2.2 Data Product Canvas

A visual innovation tool, the "Data Product Canvas", developed in a previous design science research paper by Fruhwirth et al. (2020) aims to help organisations in developing, structuring and communicating ideas for data-driven services. The newly conceptualised canvas (see schematic representation in Figure 1) consists of five main categories (dimensions): "Data Sources", "Analytics", "Data Product", "Benefit" and "Pains and Gains". The dimension "Data Sources" specifies the essential data sources for the service. "Analytics" describes common and advanced data science methods to generate insights from data. The insights are delivered and presented via the "Data Product" dimension to the internal or external customer or user. The user gains a certain "Benefit" in a specific decision-making process by using the insights presented in the data product. In order to create value for the data service user, the data product is addressing "Pains and Gains", specifically decision problems of the user.

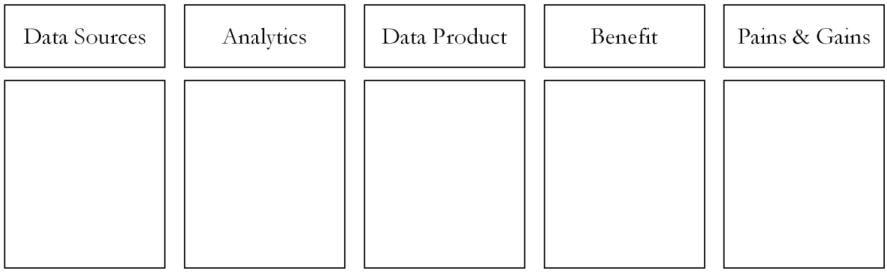


Figure 1: Schematic representation of the Data Product Canvas

Based on the solid basis of the Data Product Canvas as a visual tool for supporting the innovation of data-driven services we applied the previously described 5 dimensions as meta-categories for the card development process (see section 4.1)

2.3 Cards as an innovation method

One of the main driving forces in idea generation workshops is the diversity of its participants. (Rietzschel et al 2006). Cards are a tool commonly used to facilitate creativity and co-creation amongst people with different backgrounds. (Kwiatowska et al., 2014). Research and experience show that the use of cards supports creativity

whilst maintaining the focus on the relevant subject(s). They also stimulate discussion, group work and help when working with categorisation. (Sanders et. al 2010)

Cards are used in different areas, industries and are covering many topics. Innovation facilitating experts already apply cards as a powerful tool in participatory design and creativity workshops. For example, the Business Model Patterns Cards developed by Gassmann et al. (2013). The research team derived a number of patterns with regards to business model innovation, categorized its findings and designed 55+ cards which enable people without expert knowledge in business model innovation to reinvent, evaluate or develop a new or existing business model.

Cards are an especially adequate tool at the very beginning of an innovation process when the focus lies on generating as many solutions as possible and the main obstacle is lack of inspiration. Research has shown that the haptic aspect of cards stimulates the creative process (Gassmann et al., 2013, Kwiatowska et al., 2014, Sanders et al 2010, Hornecker 2010). Albeit it is not only the tangible, physical aspects of cards that stimulate inspiration and creativity. It is also the way cards are designed with respect to their content such as pictures, text and other information such as visible categorisation or examples.

It is important that each card is self-explanatory and easy to understand but at the same time contains all the essential information relevant to the creative process (Gassmann et al.,2013). The selection of suitable, meaningful pictures to support the written information or adding stimulating questions also plays an important role in the usability and applicability of cards in the creative process. (Hornecker, 2010)

3 Method - Design Science Research

For the structured development of the artefact (Data Service Cards), we conducted a Design Science Research (DSR) project (Hevner et al., 2004). We allocated our research activities along the process model of Vaishnavi and Kuechler (2015), consisting of the phases "Problem Awareness", "Suggestion", "Development", "Evaluation" and "Conclusion". Table 1 reports on the conducted activities, applied

methods and outcomes of the first design cycle for the present research work and the further planned activities.

Table 1: Design Science Research Phases according to Vaishnavi and Kuechler (2015)

Phase	Method / Activities	Outcome
Problem Awareness	Observation of the problem in the creativity phase in data-driven innovation projects. Interviews with R&D managers of different industries.	Difficulties to balance different backgrounds and level of expertise of innovation teams within the creative phase (idea generation) of data-driven products/services. Lack of inspiring application examples and easy to understand explanations of e.g. data analytics methods.
Suggestion	Review of existing research (see section 2). Applying meta-categories from the Data Product Canvas (see section 2.2). Suggesting design of cards following Gassmann's example on 55 Business Model Patterns.	Concept for a set of cards for supporting the idea generation of data-driven products/services.
Development	First step: Classification of sample data through qualitative content analysis into 4 meta-categories. Second step: Iterative clustering of sub-categories (individual researcher and expert team). Third step: Content creation for the cards (text and pictures).	Relevant sub- categories for data-driven products/services out of an empirical data-set. Card design for each sub- category containing explanatory picture, an explanation text and an application example.
Evaluation	Idea generation workshop for data-driven products/ services with 18 companies including documented observations. Pen & paper survey about usefulness, perception and usability.	Indications regarding usefulness, clarity and completeness. Suggestions for improvements for a second design cycle.
Conclusion	Lessons learned workshop with card development team.	Start of a second design cycle through integration of the evaluation results. Further evaluation workshops planned.

Further details regarding the methods used as described in Table 1 can be found in the following chapters 4 and 5.

3 Development and Demonstration

We base our artefact developments on an analysis on data-driven product/service idea creation projects carried out at a European applied research institute. The selected projects executed at the institution in the years of 2018 and 2019 were following a standardized self-developed process which aims to generate and evaluate ideas for data services. These projects were conceived as 2 days of innovation workshops with innovation experts and data scientists from the research institution and an interdisciplinary team (6-10 participants) from the contracted company. Within a sequence of phases, different innovation methods were applied to identify ideas with the best possible effort-benefit ratio. Overall, 122 data-driven product/service ideas were generated throughout 7 company projects.

The data sample outlined in Table 2 is characterised as follows:

Table 2: Overview on data sample

No. of project	Domain	No. of employees	No. of service ideas
Company 1	Finance	5.000	18
Company 2	Public Service	500	27
Company 3	Renewable Energy & Environment	500	14
Company 4	Mechanical Engineering	1.000	14
Company 5	Pharmaceuticals	10.000	10
Company 6	Energy utility	5.000	20
Company 7	Energy utility	500	18

For each of the aforementioned 122 ideas, one main information template (see Figure 2) was compiled during the ideation and evaluation process. It contains a summary of developed information, in particular a description of the idea, expected benefits, data inputs, nature of the analytical function, desired function output and a presentation of the data inventory.

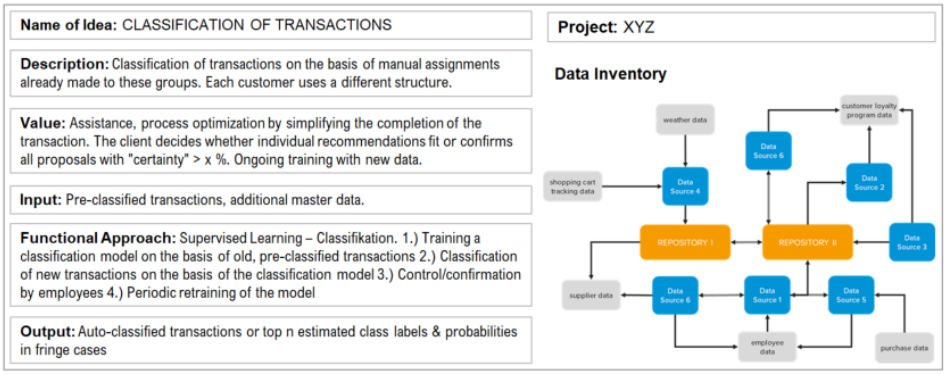


Figure 2: Exemplary description of a data product/service idea.

4.1 Categorisation

For the development of the subcategories, we followed a two-step approach. First, two independent researchers conducted a qualitative content analysis and classified the content of the 122 documented ideas (see example in Figure 2) where appropriate and possible, according to the 5 meta-categories (dimensions) outlined in section 2.2. The dimension "Data Sources" is linked to the data inventory and input information, the "Analytics" dimension to the description of the functional approach. The general description and output of the idea can be assigned to the "Service" dimension and the value information to the "Benefit" dimension. Since the data situation for the 5th dimension "Pains & Gains" was rather sparse and very company-specific, we refrained from using this dimension as a main category for the card-set. Another reason for the exclusion of this dimension was that the identified gains and pains could be assigned as counterparts to the "Benefit" dimension (no information gain). Furthermore, the assignment to the four dimensions was sufficient to specify a data product/service idea. The results of the assignments were

compared and any discrepancies that occurred were resolved through joint discussions.

Second, a cluster analysis was carried out by one independent researcher per dimension. The respective results were discussed in an extended group of experts (6 persons) in two iteration cycles. The final clustering result of the respective dimension is shown in Tables 3-6.

Table 3: Categorization of data sources

Data Sources	no. of ideas
Weather data	16
Geoinformation data	29
Product-generated data	82
User behaviour	61
Web content	31
Marketing and sales data	30
Logistics and mobility data	9
Process data	30
User-generated data	64
Open data sources	28

Table 4: Categorization of data services

Data Service	no. of ideas
Automated actions	25
Decision support	82
Data interface (API)	29
Automated report	69
Dashboard	25
Web element and software function	63
Key performance indicators	33
Benchmark	25
Raw data	19
Notifications	52

Table 5: Categorization of benefits

Benefit	no. of ideas
Information and Knowledge gain	92
Proactivity	56
Image gain	25
Customer satisfaction and trust	61
New customer acquisition	29
Cost optimization	50
Time optimization	58
Quality optimization	47
New revenue streams	11
Flexibilisation and dynamisation	28

Table 6: Categorization of analytics

Analytics	no. of ideas
Reinforcing learning	4
Classification	39
Cluster Analysis	41
Regression analysis	44
Recommendation service	28
Outlier detection	21
Natural Language Processing	44
Association rule learning	23

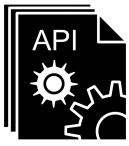
4.2 Design of Data Service Cards

For designing the Data Service Cards, the authors applied the design principles from the literature on cards as an innovation tool (section 2.3) as well as the developed subcategories per dimension (see section 4.1). Each card (front and backside) contains an explanatory picture (frontside), an explanation text (top of backside) and an application example (lower backside). The content creation process was carried

out by one or two researchers per dimension. The script for each card was revised in two iteration cycles by the entire research group. The graphic layout of the cards and the selection of the explanatory pictures were supported by an external partner.

Overall, we created content for 38 cards, 4 explanation cards for each dimension (data sources, data analytics, data product/service, customer benefit) and 2 general explanation cards (usage introduction). Table 7 shows an example of the content of one card per main category.

Table 7: Example cards per main category

Text/Pic (frontside)	Explanation text (backside)	Example text (backside)
DATA SOURCES Web Content 	The internet as a data source is almost inexhaustible and can of course also be used systematically to search for information. This is done using special computer programs (crawlers) that automatically search the World Wide Web for specific content such as search topics, offers, email addresses or links.	The TRENDONE trend explorer systematically searches the web with the help of web crawlers in order to discover trend-setting products, services or technologies. These information are provided to customers in an user-friendly way for early reaction or as a source of inspiration.
ANALYTICS Natural Language Processing 	Natural Language Processing (NLP) combines linguistics and computer science to process, and in the context of a certain problem understand natural language data such as text documents or voice recordings. Rules and algorithms are used to process large amounts of knowledge automatically, or to provide natural interaction between humans and computers.	Google uses NLP in a wide variety of areas. Google's Assistant uses NLP methods to identify the user's information needs. The search engine uses NLP to determine similarities between documents, to display structured information from web pages in info boxes or to list similar questions. Another field of application is the machine translation service Google Translate.
DATA SERVICE API 	An Application Programming Interface (API) is a software interface that enables the exchange of machine-readable data between programs, websites or data storage systems.	Google Maps API enables other companies to integrate Google's map material into their own applications (e.g., websites or apps). BMW's car sharing service DriveNow, for example, used this interface to locate vehicles.
BENEFIT Customer Acquisition 	Employ your data to better understand how to acquire new customers and leverage your current ones to grow your business.	Hydrique generates real-time inflow forecasts of water flows for hydropower producers. In parallel, local communities have emerged as new customers by requesting these information for flood protection.

5 Evaluation

The first evaluation of the Data Service Cards was carried out in the course of an idea generation workshop for data-driven products/services organised by a cluster organisation. 18 representatives from different companies of the green-tech industry were invited to test the DSC in a half-day (4 hours) workshop. The participants were divided equally among 3 groups. Each group was supervised by one researcher. After a short introduction into data-driven business, the DSC were explained using commonly known data services. Subsequently, the 3 groups were requested to perform 3 different tasks by using the DSC.

1. Joint reconstruction of a commonly known data-service by using DSC
2. Joint development of a new data service starting with "Benefit" cards
3. Joint development of a new data service starting with "Data Sources" cards

During the execution of the three tasks, three researchers (one per group) observed and documented the participant's behavior and their interaction with the DSC. Before the end of the workshop, the participants were asked to fill in a brief feedback questionnaire about usefulness, perception and usability (see Figure 4).

Generally, the DSC are well understood and perceived as helpful. The layout and design of the cards were also highlighted as positive. After a first getting to know the cards the participants mostly started intuitively with dimension "Benefits" and tried to perform the first task. For some participants, it was difficult to decide which card to select if several cards could fit. A comparison between task 2 and 3 showed that it is more difficult to develop a service based on "data sources" than starting with "benefits". When following discussions of the participants it was pointed out that categories are missing, some explanations of the cards are not clear enough and some distinctions between cards could be better.

The results of the feedback questionnaire (Figure 4) show, in general, positive feedback, especially on usefulness and ease of use of the DSC.

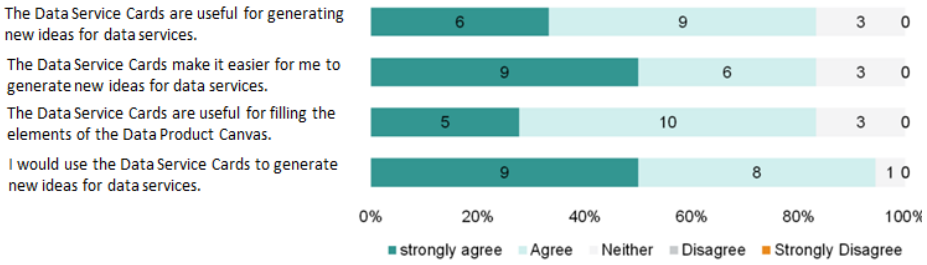


Figure 3: Results of the feedback questionnaire

The first evaluation results show already implications for changes in content and design. In a second design cycle, the following improvement topics are planned:

d) Rework of distinction of some subcategories e.g. in dimension "Benefits"
e) Improve the clarity of subcategory descriptions(e.g. sub-category "Dashboard")
f) Add new categories in dimension "Analytics" e.g. descriptive statistics
g) Insert consecutive numbering on cards
h) Provide an English version of the DSC

6 Discussion Outlook and Conclusion

The present paper demonstrates the development process of a supporting artefact (the Data Service Cards) which aims to facilitate the complex process of generating data products and services. The paper contributes to the challenging collaboration of different disciplines and level of expertise which is needed to develop a data-driven business. Together with the developed subcategories the outcome of the paper are a valuable addition to already existing tools e.g. in combination with canvas artefacts. The results of the first evaluation show that the DSC are both perceived as helpful and easy to use.

Since the development of the DSC has only gone through a first design cycle, our research implies certain limitations. As outlined in the evaluation results and also based on the limited data sample, the derived subcategories do not claim to be complete. The effects of not considering the 5th dimension "pains & gains" due to

the data situation also represent a limitation of the research. It would be interesting whether and in what form this information could be integrated into the card tool. A further limitation is shown by the fact that the evaluation was only carried out once and therefore no valid conclusions can be drawn regarding the effectiveness of the cards.

Further research projects could address a detailed investigation regarding the effect of the cards as ideas stimulus versus a possible limitation of creativity by given categories. Another research stream could explore the effect of how cards as an innovation tool (DSC) could support visual collaborative tools (canvas) in the idea generation process. In general further evaluations of the DSC concerning different domains, different company sizes and different evaluation settings are needed. Since the DSC are currently available only in German language with local company examples, an English version with international company examples is already in progress. Research results from tests and evaluations in an international environment would be very valuable for the further development of the DSC. Finally, further research is needed on how the current tool can be used to develop business based on new enabling technologies (e.g. anonymisation, privacy-preservation).

Acknowledgements

The research based on this paper has received funding form the European Union's Horizon 2020 innovation program under grant agreement No 825225. The authors wish to thank the colleagues from the Green Tech Cluster Styria for their support throughout the development process.

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RIDE-HAILING APP STRATEGIES OF FINNISH TAXI DISPATCH ORGANIZATIONS

KARIN VÄYRYNEN[1]

[1] University of Oulu, Faculty of Information Technology and Electrical Engineering, Oulu, Finland, e-mail: karin.vayrynen@oulu.fi

Abstract The Finnish taxi industry has already long been technologically developed, and since 2011 taxi hailing apps have been available in Finland. The amount of these apps has steadily increased, spurred by the arrival of Uber and Taxify in Finland in 2014, and by the de-regulation of the Finnish taxi industry in July 2018. In the present paper, the aim was to identify ride-hailing app acquisition related strategies that traditional Finnish dispatch organizations (DOs) employ. A qualitative case study with five focus organizations was conducted between 2018-2020. This study contributes to extant research in two ways. First, by identifying five ride-hailing app strategies employed by DOs (three related to the question of make vs. buy, two related to discontinuing/selling). Second, by showing that different ride-hailing apps can play different strategic roles – which helps explain DOs' multihoming strategy – and that the strategic role of a specific ride-hailing app can change over time.

Keywords: taxi dispatch organization, ride-hailing app, app acquisition, app sourcing, multihoming, taxi industry.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.41
ISBN 978-961-286-362-3

1 Introduction

Taxi hailing platforms such as Uber, Taxify, Didi and Yango offer consumers the possibility to order or "hail" rides via an app (Harding et al. 2016). When Uber entered the San Francisco market in 2010, this service that allowed consumers to hail a ride with an app was quite unique. In 2014, Uber and Taxify (named Bolt in March 2019) entered the Finnish market, and only few other ride-hailing apps had been available at that time in Finland. Now, partly due to a de-regulation of the Finnish Taxi market in 2018 (Heikkilä and Heikkilä 2019), an abundance of ride-hailing apps is available in Finland. Interestingly, most of these apps are not provided by international ride sharing platform providers, but by traditional Finnish taxi dispatch organizations (DO). These DOs' apps represent a mobile channel (Crittenden et al. 2017) for ordering taxi rides, in addition to the more traditional channels such as phone, email, text message, and street hailing.

Extant research on ride-hailing apps has mainly focused on apps provided by large, internationally operating organizations such as Uber, Lyft and Didi (e.g., Zhang et al. 2020, Leng et al. 2018, Harding et al. 2016). Research on ride-hailing apps provided by smaller, local taxi dispatch organizations (DO) has been very rare (exceptions include Väyrynen et al. 2018; Niemimaa et al. 2019 touch upon the topic).

In order to provide a ride-hailing app, i.e., a mobile channel to hail a ride, the DO first has to acquire such an app – and whether to make or buy a good such as a mobile app is an important strategic question for the organization (Williamson 1973). Against this backdrop, we ask the following research question: "*What strategies related to ride-hailing app acquisition do traditional taxi dispatch organizations employ?*"

To answer this question, we conducted an empirical qualitative case study among a taxi owner-drivers' federation and four traditional taxi DOs and analyzed what different strategies they employed regarding ride-hailing apps. We make two contributions to extant research. First, we identify five different strategies traditional DOs employ related to providing consumers with the possibility to hail a taxi ride via an app. Second, we show that different ride-hailing apps can have different strategic roles (which can change over time). This helps explain why not only drivers and customers, but also DOs use several ride-hailing apps simultaneously, i.e., multihome.

2 Make or buy as strategic options for software acquisition

One important strategic question for any organization is how to acquire a good - whether to make or buy it (Williamson 1973). 'Make' refers to producing a good in-house, whereas 'buy' means that it is purchased on the market. Comparative production costs for making versus buying have the greatest influence on the decision of whether to make or buy something, but also volume uncertainty and supplier market competition affect the decision (Walker and Weber 1987). This logic can also be applied to software as a good, which mobile apps represent. From a strategic point of view, previous research has distinguished between different types of software. We here subscribe to Väyrynen and Iivari's (2015) distinction between commercial off-the-shelf software (COTS), customizable/configurable software, and tailor-made software. COTS is software where many copies of the product are sold, that can be purchased on the market, and that is ready-to-run, whereas tailor-made software is developed for a specific company's needs with only one copy of the software being produced (Xu and Brinkkemper 2007). Tailor-made software can be developed in-house or can be contractual tailor-made by an external software provider (ibid.). Customizable/configurable software, e.g., ERP software, is ready-made but not ready-to-run (Väyrynen and Iivari 2015). It can be purchased from a software provider but has to be configured (i.e., adjustments are made to software parameters without changing the software at the code-level) or customized (changes made to the software at the code level) before it can be used (Lee et al. 2003; Light 2001). From a strategic point of view, Software-as-a-Service (SaaS) is comparable to COTS software, as both are available to all on the market (Väyrynen and Iivari 2015). Whereas in COTS the customer pays a one-time fee and possesses full ownership of the software, in SaaS the customer usually pays a fee per transaction (Ma 2007). To summarize, the main strategic options for acquiring software (e.g., a mobile app) are to buy software (e.g., COTS/SaaS, customizable/configurable, or contractual tailor-made software) or make it (in-house developed tailor-made software).

3 Research methodology

Case and research context. The first Finnish taxi hailing app appeared in 2011. In 2014, both Uber and Taxify entered the Finnish market with their apps. In contrast to Uber who only collaborated with drivers, Taxify also sought collaboration with traditional DOs. DOs do not own the taxis they dispatch, but most DOs are owned

by the entrepreneurs whose cars are dispatched by the organization. During the past 2 years, the Finnish taxi industry has undergone the biggest changes in its history. Having been one of the most strictly regulated taxi markets in the European Union, it was de-regulated in July 2018. Before the de-regulation, the taxi market had been separated into geographic areas, each geographic area being served by one taxi DO. The number of taxi licenses was regulated, and the Finnish government defined the maximum taxi prices. With the de-regulation, the number of taxi licenses was not any more fixed, prices were not any more regulated, and DOs were overnight competing. It is in this context that more and more DOs started to acquire ride-hailing apps.

Data collection. This research is part of a larger, longitudinal research project on the digital transformation of the Finnish taxi industry which has been ongoing since autumn 2017. The present research is a qualitative, interpretive case study (Walsham 1995). For the present study, 20 interviews (see Table 1) were analyzed that were conducted with 4 DOs (Alpha, Beta, Gamma, Delta) in different regions in Finland, Taxify, a provider of contractual tailor-made software, and the Finnish Taxi Owner-Drivers' Federation (FTOF) who developed a taxi hailing app for DOs.

Table 1: Interviews with focus organizations

Organization	Interview # (when conducted, interview length)
FTOF	**Int 1** (Q1/2018, 1:15:15); **Int 2** (Q1/2018, 1:27:36); **Int 3** (Q1/2018, 1:35:07); **Int 4** (Q4/2018, 1:39:43); **Int 5** (Q4/2018, 1:50:55); **Int 6** (Q4/2019, 2:12:52)
Alpha	**Int 7** (Q1/2018, 1:39:20); **Int 8** (Q4/2018, 1:32:03); **Int 9** (Q4/2019, 1:08:14); **Int 10** (Q4/2019, 0:48:21)
Beta	**Int 11** (Q1/2018, 1:48:07); **Int 12** (Q2/2018, 0:31:00); **Int 13** (Q4/2018, 1:30:56); **Int 14** (Q4/2019, 1:29:25)
Gamma	**Int 15** (Q4, 2018, 3:38:30), **Int 16** (Q4, 2019, 1:46:54)
Delta	**Int 17** (Q4/2018, 2:17:35); **Int 18** (Q1/2020, 1:16:30)
Software provider	**Int 19** (Q1/2018, 1:25:55)
Taxify	**Int 20** (Q1/2018, 1:04:06)

Qualitative interviews represent one of the most important data gathering sources in Information Systems research (Myers and Newman 2007) and were the main source of information in this study. The interview themes revolved around the digitalization of the Finnish taxi industry, taxi hailing apps, the change of the law in July 2018 and its effects on the industry. In some interviews, two interviewees participated. All interviews were transcribed. Quotes are translations from Finnish to English.

Data analysis. NVivo software (version 12) was used when analyzing the interviews. First, all text passages were extracted from the interviews that concerned those apps that were available in the Finnish taxi market and through which rides dispatched by Finnish taxi DOs could be ordered. Second, information was extracted regarding the ride-hailing app strategies the focus organizations (FTOF, Alpha, Beta, Gamma, and Delta) employed over time. A timeline was created for each focus organization regarding when a certain app was acquired or sold or its use discontinued. Information from the interviews was triangulated with information from print media articles and material received from the organizations. As a result of the data analysis, five different strategies (see Table 2) were identified. The term "app" is used henceforth, while acknowledging that a ride-hailing app is not a stand-alone software but has to be integrated with some platform or dispatch system to function.

4 Findings

Next, for each focus organization the ride-hailing app acquisition related strategies that it employed over time are described. Five different ride-hailing app strategies (referred to as S1 – S5) could be identified: (S1) develop a ride-hailing app in-house, (S2) join an existing ride-hailing app/platform, (S3) purchase a ride-hailing app/platform, (S4) sell a ride-hailing app/platform, and (S5) discontinue use of a ride-hailing app/platform.

FTOF

The FTOF supports its members' (taxi entrepreneurs and DOs) interests. Based on discussions initiated in 2013, in 2014 the FTOF's business unit started to develop a taxi-hailing app in-house **(S1)** which would then be provided to the Finnish DOs. FTOF App was launched in April 2015. One reason for why the FTOF started developing the app was: "*Most of the DOs that are members of the FTOF are so small, and I also count our DO to those, that we do not have the resources to build our own app. […] Those large DOs who have more than 1000 cars, 4000 drivers, they have enough volume that it makes sense [for them]F to develop their own app.*" (Beta representative) The FTOF App was integrated over the following two years with more than 30 Finnish DOs using five different types of dispatch systems. The DOs paid a fee to the FTOF's business unit for each taxi ride that a customer ordered via FTOF App. The app was successful and used all over Finland, thus representing *the* app through which consumers could hail a taxi ride almost anywhere in Finland. After having provided the app for 2 years,

in the light of the coming de-regulation of the law, the FTOF decided to sell FTOF App to the highest bidding Finnish DO **(S4)** in spring 2018.

Alpha (large dispatch organization)

Alpha developed in-house and launched its first taxi hailing app (Alpha App 1) in 2011 **(S1)** and launched several updates of the app over the years. Alpha joined FTOF App in 2015 **(S2)**. In 2016, Alpha App 2 replaced Alpha App 1 **(S5)**. Alpha App 2 was developed in-house **(S1)**, with functionalities very similar to those of Uber at the time. In November 2017, Alpha discontinued the FTOF App collaboration **(S5)**. Especially two factors affected this decision: first, the slow technological development of FTOF App due to the need to integrate FTOF App with five different dispatch system types used by Finnish DOs. Second, the soon-to-come de-regulation of the Taxi market: as competition was expected to increase strongly, Alpha wanted to make sure their customers would be tied to their own Alpha App 2 instead of to FTOF App. In spring 2018, Alpha purchased FTOF App when it became available for sale **(S3)**: "*Why we purchased FTOF App? Because it was for sale. That's a quite good answer, that if such a good product is for sale, then why would we not have wanted to buy it? […] it's a working system and has maybe also future potential.*" In addition, Alpha started to offer its taxi dispatch services also to other geographic regions in Finland, and as part of this also offers their own app under a different name to other DOs **(S4)**. Alpha thus used Alpha App1/Alpha App 2 concurrently with FTOF App between 2015-2017, and from spring 2018 onwards.

Beta (mid-sized dispatch organization)

In November 2014, Taxify entered the Finnish market and sought to collaborate with Finnish taxi DOs and individual drivers. Beta was one Finnish DO that joined the Taxify platform **(S2)**. The decision to collaborate with Taxify was made with the expectation that Taxify would become a large international player that would increase customer numbers for Beta, and because Beta wanted to offer its customers an additional channel to hail cars apart from its more traditional channels (e.g., phone, email, text message, online form, street hailing). Taxify App was not integrated with Beta's dispatch system, and taxi drivers had a separate phone in the car to take rides that customers ordered through Taxify App. In autumn 2015, Beta joined FTOF App **(S2)** because this app was expected to be more widely used than

if Beta would have developed or purchased an own app. Beta used Taxify App and FTOF App concurrently for one year, before it ended its collaboration with Taxify **(S5)** in autumn 2016. One reason for discontinuing Taxify App use was that Taxify App was more expensive for them to use than FTOF App. When FTOF App became available for sale in 2018, Beta participated in the bidding **(attempted S3)** which Alpha won. Due to speculations whether Alpha would be purchased by a big international taxi corporation, Beta feared to be dependent on an app owned by a (due to the legal change) soon-to-be competitor. They thus decided to also acquire an own app: "*We wanted to make sure that the control and ownership of our app rides would not directly flow to one of the biggest competitors*." When the attempted purchase of FTOF App failed, Beta considered whether to acquire the app offered by their dispatch system provider, or a contractual tailor-made app. Beta was mainly concerned that the costs of integrating a contractual tailor-made app with their dispatch system would be very high. Thus, Beta purchased Beta App **(S3)**, the taxi hailing app provided by their dispatch systems provider, as this was the fastest way to get a working app into use already in autumn 2018. Alpha was not sold to the international competitor, and Beta felt that they maybe should have acquired a tailor-made app, as they are a bit dis-contented with the Beta App. At present, Beta uses both FTOF App and Beta App.

Gamma (large dispatch organization)

Gamma launched its first app, Gamma App 1, in 2015. This app had come as part of the dispatch system that Gamma had purchased **(S3)**. In addition, also Gamma joined FTOF App in 2015 **(S2)**, but discontinued FTOF App use **(S5)** in 2018, when Alpha purchased FTOF App. Gamma has not been quite contented with Gamma App 1: *"From a usability perspective it was almost impossible: very rambling boring and difficult and really bad. We right away told them we were discontented, that usability is not at a present-day level."* Despite promises from the dispatch system provider over several years, the agreed-on improvements to Gamma App 1 were not made. Therefore, in spring 2018, Gamma started to make specifications for the kind of app they were looking for, negotiated with different app providers, and finally ordered Gamma App 2 to be developed by a Finnish software company **(S3)** which already had developed several other taxi hailing apps. After four months of development, Gamma App 2 was launched in November 2018 and Gamma App 1 use discontinued **(S5)**. Gamma App 1, if already installed on a customer's phone, was automatically updated to

Gamma App 2. Between 2015-2018, Gamma used both FTOF App and Gamma App 1, whereas at present (May 2020) they only use Gamma App 2.

Delta (mid-sized dispatch organization)

Delta joined and was integrated with FTOF App in April 2015 **(S2)**. Even though Delta was contented with FTOF App, they felt that ownership and control aspects were problematic: "*There was a problem with FTOF App, and that was the ownership structure, that it was not really in anyone's control […], but in any case it was in no way in our own control.*" Therefore, they started to consider other options and decided to acquire a contractual tailor-made app **(S3)**, Delta App: "*We considered different options and collaboration options, can we make an application together with several other actors, and we studied existing apps and their prices, and after a lot of phases [of deliberation] we decided to acquire our own app.*" Delta made specifications for the app and then ordered it from a software company. One important aspect in purchasing their own app was control over customership. FTOF App was seen as an app that was linked to *some* taxi, but Delta App was seen as a way to link customers to Delta directly and a channel to be in direct contact with their customers. Delta App was launched in October 2018. At present, Delta uses both FTOF App and Delta App.

5 Discussion

We asked the question what strategies related to ride-hailing app acquisition traditional taxi DOs employ. We make two contributions. First, we identified five different ride-hailing app strategies employed by the focus organizations (Table 2). Three of these strategies concern the acquisition (make vs. buy) of the app (S1, S2, S3), whereas two strategies are related to the "flipside of the same coin" – strategies related to selling an app (S4) or discontinuing use of an app (S5). In line with the research question, and due to page limitations, we focus here on discussing the three app acquisition strategies (S1, S2, S3) in more detail. Second, we show that all DOs at some point in time used two different ride-hailing apps concurrently. In line with previous research we refer to this strategy as multihoming. One possible reason for multihoming are the different strategic roles that different ride-hailing apps play.

Table 2: Ride-hailing app strategies employed by focus organizations

Org	S1 (develop)	S2 (join)	S3 (purchase)	S4 (sell)	S5 (discontinue)
FTOF	FTOF App			FTOF App	
Alpha	Alpha App 1 Alpha App 2	FTOF App	FTOF App	Alpha App 2	Alpha App 1 FTOF App
Beta		Taxify FTOF App	Beta App (CS)		Taxify
Gamma		FTOF App	Gamma App 1 (CS) Gamma App 2 (CTM)		FTOF App Gamma App 1
Delta		FTOF App	Delta App (CTM)		

Legend: contractual tailor-made software (CTM); customizable/configurable software (CS)

One important strategic question for an organization is whether to make or buy a certain good (Walker and Weber 1987). In-house tailor-made software represents the **"make" strategy**, whereas COTS/SaaS, customizable/configurable software, and contractual tailor-made software represent options for a **"buy" strategy** (Xu and Brinkkemper 2007; Väyrynen and Iivari 2015). The strategies we identified correspond well to these strategic options. The strategy to develop a ride-hailing app in-house (S1), and to buy customizable/configurable software or contractual tailor-made software (both represented in S3) was employed by several DOs. Only Alpha developed their ride-hailing apps in-house, being a technological forerunner amongst Finnish DOs with their first ride-hailing app implemented already in 2011 when no suppliers for ready-made ride-hailing apps existed, only leaving the option of a tailor-made app. The competition of suppliers for a certain good influences the decision whether to make or buy a good (Walker and Weber 1987), and in the ride-hailing app market, the number of these different suppliers and strategic options for DOs to acquire a ride-hailing app certainly increased since 2014. Both the strategy to acquire a configurable/customizable app provided by the dispatch system provider (e.g., Beta App, Gamma App 1), and the strategy to order a contractual tailor-made app (e.g., Gamma App 2, Delta App) were employed by Finnish DOs. Acquisition of an app that was not provided by the dispatch system provider that the DO already used usually meant a more difficult technical integration of the app with the dispatch system. In addition to the different available (potential) providers of ride-hailing apps, also the DO's available financial resources affected the app-strategy. Most Finnish DOs are small and do not have the resources to develop an app, which was

also one of the reasons why the FTOF business unit started to develop FTOF App. In addition to the above strategies, we also identified the **strategy to join an existing app** (S2). This strategy was employed by Alpha when collaborating with Taxify, but also by all four DOs in connection to FTOF App. In the context of ride-hailing, the strategy to join a ride-hailing app has been addressed concerning whether drivers or consumers choose to join a ride-hailing app as service providers or service consumers (e.g., Belleflamme and Peitz 2019). With our study, we show that this question surprisingly is also relevant for DOs, who otherwise act as the intermediary between drivers and customers. When considering what of the strategic options for acquiring an app this represents, we made an interesting observation: in this strategy, the DO did not buy the app, but paid the provider of the app (e.g., Taxify, FTOF business unit) a transaction-based fee. SaaS refers to software that is not owned by the customer (in contrast to COTS) but where customers pay based on the transactions done with the software (Ma 2007). Thus, Taxify and FTOF business unit could be seen to have acted as a "mobile app as a service" providers for Finnish DOs. DOs paid also a transaction-based fee for rides that had been hailed with FTOF App and did not own the app themselves, which would fit the SaaS scheme. However, there is one important difference between FTOF App and Taxify: FTOF App had to be integrated with the DO's dispatch system, whereas Taxify did not. COTS ride-hailing apps do not seem to exist for dispatch organizations, as these apps seem to require quite effortful integration with the DO's dispatch system.

Our second contribution concerns our finding that all DOs in our study at one time or another used simultaneously two different ride-hailing apps through which customers could order rides dispatched by that organization. Previous research has referred to the situation where service providers (such as DOs represent by providing their dispatch services to drivers and consumers) use different, competing platforms as "**multihoming**" (Belleflamme and Peitz 2019). In a ride-hailing (e.g., Uber, Lyft) and renting (e.g., AirBnB) platform context, multihoming has referred to situations where drivers/hosts offer their services concurrently in several ride sharing or rental platforms, or where consumers (e.g., riders, renters) use several platforms to search for the best price (e.g., Bryan and Gans 2019). We argue that when DOs provide their customers and drivers with two or more ride-hailing app channels, this, too, represents multihoming. The question then is why DOs engage in this practice? One reason is that **different ride-hailing apps play a different strategic role** for the DO and serve different types of customers. FTOF App

compared to DOs own "branded apps" is a good example of different strategic roles of ride-hailing apps. FTOF App – first developed when Finnish DOs represented regional monopolies and did not compete with each other – at that time represented a possibility for practically all Finnish DOs to offer their customers a mobile channel (Crittenden et al. 2017) to hail a ride. However, through the de-regulation of the industry, which turned DOs from regional monopolies into competitors, the importance of tying the customer to a specific DO significantly increased. Previous research already found that apps can take a role in the branding efforts of organizations (Zhao and Balagué 2015). The present research shows that the DOs own "branded" apps fulfil the strategic role of tying the customer to a specific DO. In contrast, nowadays FTOF App has the role of serving especially customers that travel within Finland and with which rides can be hailed from different DOs all over Finland. Therefore, the different roles that FTOF App and DOs' "branded" apps play offer one explanation for why DOs multihome. In this context we also want to point out that **the strategic role of a specific ride-hailing app for a DO is not static** – it can change over time. A good example of this is FTOF App. It changed from a sought-for digital taxi hailing channel to a channel that was *not* tying customers directly to the DO. Then, when Alpha purchased the FTOF App in 2018, the app even turned into a potential threat as some DOs feared they might lose their customers to their competitor. This change in the strategic role of an app is also one reason for why a DO might acquire (S1, S2, S3), sell (S4), or discontinue use of a ride-hailing app (S5).

To summarize, which ride-hailing app strategy a DO employed at what point in time was dependent on the available options for acquiring or joining an app, financial resources available, urgency of acquiring an app (buying an existing app is usually "faster" than tailor-made software development), strategic role of an app, ownership over an app (who "owns" the customers), and changes to the institutional environment (from a heavily regulated to a de-regulated industry).

6 Conclusion

We asked what strategies related to ride-hailing app acquisition traditional taxi DOs employ. We make two contributions. First, we identified five strategies employed by the four Finnish DOs in the focus of the study. Three represented the make vs. buy options for acquiring an app (developing an app in-house, joining an existing app, and purchasing an app), whereas two are related to the flipside of that coin (selling

an app, and discontinuing use of an app). Second, we show that the concept of multihoming – i.e., of using more than one ride-hailing app simultaneously – not only applies to drivers and riders, but also to DOs. We explain this strategic choice through our observation that different ride-hailing apps can play different strategic roles. Our study has ***practical implications*** for DOs by pointing towards different options for ride-hailing app acquisition, and by drawing attention to the question of what strategic role a certain ride-hailing app can or should play. Our research also has ***limitations***. We focused specifically on identifying the strategies employed, but not on the process of strategizing in more detail. In addition, our research is conducted in Finland at a time of a taxi industry de-regulation, and our findings thus might not be applicable to other contexts (e.g., taxi markets that are regulated differently). ***Future research*** should investigate in more detail the different aspects that affect, and practices that are related to, DOs' ride-hailing app strategies.

Acknowledgements

The author is very grateful to the Jenny and Antti Wihuri Foundation and GenZ project for their financial support, to Dr. Arto Lanamäki for his invaluable contribution during our joint project, and to the participating organizations for the time and insights they provided.

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Attitudes Toward Microchip Implant in Groups Pro and Con its Insertion for Healthcare Purposes

Anja Žnidaršič[1], Alenka Baggia[1] & Borut Werber[1]

[1] University of Maribor, Faculty of organizational sciences, Kranj, Slovenia, e-mail: anja.znidarsic@um.si, alenka.baggia@um.si, borut.werber@um.si

Abstract The perception of new technologies and medical interventions in the human body changes over time. Attitudes towards new technologies, health issues and approaches differ according to the gender, age, education, place of residence and background of the individual. Our research on the adoption of microchip implants for healthcare purposes has identified two main groups of people: those who would be willing to use microchip implants for healthcare purposes and those who reject this option without considering its use. This study examines the differences in the general opinion on microchip implants between respondents for and against their use for healthcare purposes. An online survey was conducted in four European countries. More than half of the respondents were inclined to use a microchip implant for healthcare purposes. Statistically significant differences in general attitudes towards microchip implants exist between the groups of respondents who are for and against the use of a microchip implant for healthcare purposes. The most significant difference is in perceived usefulness, which shows that respondents who are inclined to use microchip implants for healthcare purposes consider the technology more useful than those who are against it. All respondents disregarding their willingness to use microchip implants showed privacy concerns.

Keywords: healthcare, microchip, implant, international, comparison.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.42
ISBN 978-961-286-362-3

1 Introduction

New technologies used by and in society are transforming society to the next level of digitalization. One of the main areas in this process of transformation is the healthcare system, which has to become proactive (Bauer, 2007) to efficiently follow and exploit the novel technologies and trends (e.g. Lazzi, Lee, & Nikita, (2019; Virkki, Wei, Liu, Ukkonen, & Björninen, (2017)). RFID microchip implants are an example of novel technology, which can provide vital patient information (i.e., blood type, age, etc.) and can be used as an identifying device (Gillenson, Zhang, Muthitacharoen, & Prasarnphanich, 2019).

Microchip implants (MIs) have been used in healthcare for prosthetic, monitoring, and enhancement medical devices (Basham, 2014; Madrid, Korsvold, Rochat, & Abarca, 2012; Sachs & Gabel, 2004; Soares dos Santos et al., 2013). Implanted devices for therapeutic purposes to combat illnesses such as epilepsy, Parkinson's disease, and severe depression have also proved to be effective (Michael & Michael, 2013; Perakslis & Michael, 2012). Besides, MIs can affect cancer cells (Lai, Chan, & Singh, 2016). MIs can also minimize mistakes in personal medical information such as blood type, allergies, current medications, and medical history (Mohamed, 2020).

Similar to any other foreign object in the body, MIs could pose health risks (e.g. rejection, allergic reaction). For example, Albrecht (2010) identified the causal link between microchips and cancers in rodents and dogs. Therefore, we have to consider whether the benefits of implants are worth the potential health risks. The perception of MIs as secure technology differs according to the country of residence and generational factors (Perakslis & Michael, 2012). Although there are plenty of perceived reasons to reject MIs for employee identification (Michael, Aloudat, Michael, & Perakslis, 2017), MIs have been adopted by healthy people for various non-therapeutic purposes (Fram, Rivlin, & Beredjiklian, 2020).

Putting aside the privacy and security issues (Juels, 2006; Rodriguez, 2019), the advantages that MIs can bring to healthcare management in general and individual health issues are not negligible. Nevertheless, not much research was conducted to identify MI acceptance for healthcare purposes. In prior research (Werber, Baggia, & Žnidaršič, 2018), we have identified the differences between individuals who

would be willing to adopt a MI for health purposes and those, who reject the idea disregarding the purpose.

In this paper, we aim to present the differences that exist between people who are willing to implant a MI for healthcare purposes and those who reject the MIs for healthcare purposes. This research focuses on Near Field Communication (NFC) microchips that can be read at the distance up to 16 cm using a 12 x 2,2 mm microchip in a glass tube (in special conditions up to 0,6 m) (Meyer, Chansue, & Monticelli, 2006). The discussed microchips cannot be tracked by GPS or other satellite networks as well as other RFID networks that track active RFID devices.

2 Methodology

The MI acceptance study was conducted in 2016 and 2017 in four countries: Poland, Croatia, the Czech Republic, and Slovenia. For this research, we updated the pre-developed questionnaire (Werber, Baggia, & Žnidaršič, 2018) that was translated into the local language. Respondents were invited to participate in the survey via various channels, from social networks to media posts. The participants were of different ages and gender.

Items were measured on a 5-point Likert scale of agreement ("strongly disagree" to "strongly agree") or acceptability ("very bad idea" to "very good idea"). Based on our prior research (Werber et al., 2018), we have identified the differences in the attitude towards RFID MIs for healthcare purposes. Therefore, we have formulated the following research question:

RQ: Are there differences in 27 questionnaire items on attitudes toward MIs adoption between two groups according to the willingness to adopt MIs for healthcare purposes?

To answer the RQ we performed 27 Independent Samples t-tests. In the Results section, first, the sample structure and the descriptive statistics of the questionnaire items are presented.

3 Results

We received a total of 1058 partially fulfilled valid responses. Comparing samples from different countries we can see that the smallest sample (146) comes from Croatia and the largest (356) from the Czech Republic, while from Slovenia and Poland we received 288 and 268 respondents, respectively.

Among the respondents, 510 (51.1 %) would adopt a MI for healthcare purposes, and 489 (48.9%) would not (7 persons did not provide that answer). The sample structure according to the willingness to insert a MI for healthcare purposes is presented in Table 1.

Table 1: Sample structure according to the willingness to insert microchips implant for healthcare purposes

		Would you insert a MI for healthcare purposes (identification, storage of medical data, information on organ donation, etc.)?			
		No		**Yes**	
		n	**%**	**n**	**%**
Country	Poland	120	51.1%	115	48.9%
	Croatia	59	43.1%	78	56.9%
	Czech Republic	173	49.0%	180	51.0%
	Slovenia	158	57.7%	116	42.3%
Gender	Man	231	46.8%	263	53.2%
	Women	276	55.0%	226	45.0%
Status	Pupil or student	102	37.8%	168	62.2%
	Employed	339	55.2%	275	44.8%
	Unemployed	23	59.0%	16	41.0%
	Pensioner	43	60.6%	28	39.4%

Comparing the status of respondents, we can see that most respondents with a positive attitude for MI insertion for healthcare purposes come from pupil and student group (62.2%) while the lowest from elderly respondents (39.4%).

Descriptive statistics for 27 questionnaire items on Attitudes toward MIs are presented in Table 2. To answer the research question, the Independent Samples t-tests were performed (Table 3). For 25 questionnaire items, results show that there exist statistically significant differences in mean values of questionnaire items according to two groups of willingness to insert a MI at a 5 % significance level.

In the previous research (Werber, Baggia, & Žnidaršič, 2018), constructs composing of questionnaire items were defined. The same constructs are used in this research, to provide a concise representation of the results. Constructs (as presented in Table 2) are defined as follows: Painful procedure (PP), Health Concerns (HC), Safety and Control Issues (SCI), Perceived Usefulness (PU), Perceived Trust (PT), Perceived Ease of Use (EU), Perceived Threat (PTh) and Privacy Right (PR).

Table 2: Descriptive statistics for 27 questionnaire items according to two groups of interested and non-interested persons for inserting MIs for healthcare purposes

	Would you insert **MI** for healthcare purposes?					
	No			**Yes**		
Questionnaire item	**N**	**M**	**SD**	**N**	**M**	**SD**
Implanting MI is a painful procedure. (PP1)	509	2.97	1.082	487	2.72	0.982
MIs can be threatening to my health because of the possibility of movement in my body. (HC1)	507	3.20	1.129	485	2.74	1.000
MIs may affect my emotional behaviour.(HC2)	506	3.14	1.222	485	2.34	1.074
MIs can be threatening to my health because of possible allergies. (HC3)	505	3.52	1.091	480	3.01	1.052
MIs can be threatening to my health because of their impact on the nervous system. (HC4)	504	3.42	1.100	483	2.79	1.057
MI can be remotely controlled (e.g. switching off or changing settings) by an unauthorized person. (SCI1)	509	3.65	1.057	486	3.21	1.037
MIs enables higher level of control. (SCI2)	509	3.58	1.214	487	3.22	1.194
MIs technology is safe enough to be used in humans. (SCI3)	507	2.36	1.040	486	2.95	0.914
MIs could be used for:						
- monitoring health of the user. (PU1)	506	3.29	1.098	488	4.13	0.793
- warnings about potential health problems or complications. (PU2)	505	3.44	1.080	486	4.21	0.791

- storing a user's medical info to be used in an emergency. (PU3)	507	3.37	1.093	487	4.21	0.765
- personalized health info. (PU4)	506	2.95	1.145	487	3.89	0.894
- storing information about organ donation. (PU5)	500	3.00	1.143	487	3.93	0.894
- lower the health insurance premiums. (PU6)	504	2.42	1.160	488	3.60	1.091
- saving life (e.g. unconsciousness, cardiac pacemaker, sugar detector, insulin dispenser, etc.). (PU7)	507	3.44	1.064	488	4.23	0.794
The state will ensure the security and the protection of human rights (security of identity documents, passport, identity theft, tracking via GPS, no records should be archived without the consent of the person observed). (PT1)	508	2.14	1.143	486	2.95	1.188
Banks will provide security (payment, discretion of operation, transactions, etc.). (PT2)	508	2.29	1.135	485	3.12	1.151
The healthcare system will provide security (personal data**,** medical data**.** information on treatments, organ donation, etc.). (PT3)	508	2.51	1.169	486	3.58	1.073
MIs are always available. (PEU1)	509	3.31	1.044	488	3.68	0.943
MIs cannot be lost. (PEU2)	507	3.59	1.022	488	3.93	0.866
MIs cannot be stolen (high-security protection). (PEU3)	508	2.88	1.186	488	3.32	1.133
MIs can integrate multiple functions at the same time. (PEU4)	507	3.80	0.898	486	4.15	0.711
Organizations and agencies ask you for too much personal information. (PTh1)	509	4.07	0.901	487	3.81	0.982
The present use of computers is an actual threat to personal privacy in the country. (PTh2)	509	3.81	0.973	486	3.56	1.033
I am concerned about threats to my privacy in the country today. (PTh3)	509	3.67	1.104	485	3.31	1.103
No one should be able to gather or disclose your personal information without your consent. (PR1)	507	4.51	0.830	487	4.47	0.810
People should have the right to control their personal information. (PR2)	507	4.54	0.772	487	4.49	0.714

Table 3: The independent samples t-test.

	Levene's Test for Equality of Variances		t-test for Equality of Means		
Item	**F**	**p**	**t**	**df**	**p**
PP1	0.020	0.887	3.842	994	0.000
HC1	7.733	0.006	6.751	984.2	0.000
HC2	10.196	0.001	11.040	981.7	0.000
HC3	6.827	0.009	7.386	982.8	0.000
HC4	3.678	0.055	9.138	985	0.000
SCI1	0.552	0.458	6.693	993	0.000
SCI2	1.714	0.191	4.760	991	0.000
SCI3	35.889	0.000	-9.443	986.8	0.000
PU1	90.726	0.000	-13.740	919.7	0.000
PU2	66.527	0.000	-12.771	923.9	0.000
PU3	84.687	0.000	-14.059	908.1	0.000
PU4	58.359	0.000	-14.333	951.1	0.000
PU5	49.229	0.000	-14.290	941.5	0.000
PU6	8.095	0.005	-16.450	989.2	0.000
PU7	54.928	0.000	-13.366	935.7	0.000
PT1	1.153	0.283	-10.942	992	0.000
PT2	0.415	0.520	-11.437	991	0.000
PT3	15.408	0.000	-15.049	990.3	0.000
PEU1	6.270	0.012	-5.910	991.6	0.000
PEU2	37.396	0.000	-5.642	977.4	0.000
PEU3	1.239	0.266	-5.976	994	0.000
PEU4	8.967	0.003	-6.816	957.5	0.000
PTh1	6.607	0.010	4.309	977.6	0.000
PTh2	10.684	0.001	4.015	982.0	0.000
PTh3	0.319	0.572	5.065	992	0.000
PR1	*0.209*	*0.648*	*0.782*	*992*	*0.435*
PR2	*0.001*	*0.979*	*0.965*	*992*	*0.335*

It can be seen from Table 2 that the means of items differ the most in the Perceived Usefulness (PU) construct. There is a significant difference in means for the item considering that users of MIs should have lower insurance premiums. Respondents prone to MIs for HC purposes have a higher level of agreement with this statement $(M = 3.60)$ as respondents contrary to MIs for HC purposes $(M = 2.42)$. Further,

respondents prone to MIs for HC purposes are more convinced that MIs could be used for personalized health information ($M = 3.89$), as respondents contra ($M = 2.95$). A similar difference in opinion is identified in the opinion about using MIs for storing organ donation information, where respondents prone to MIs for HC purposes agree with the statement ($M = 3.93$) significantly more as the respondents contrary ($M = 3.00$). The lowest statistically significant differences were identified in the construct Privacy Threat (PTh), showing that respondents have a quite similar opinion on MI's influence on privacy.

The only construct, where we have not identified statistically significant differences in the Privacy Right construct (PR). Both items PR1 (No one should be able to gather or disclose your personal information without your consent) and PR2 (People should have the right to control their personal information) showed no statistically significant differences. All items with statistically significant differences between the two groups of respondents are presented in Figure 1. Figure 1 presents error bars for each item according to 2 groups, meaning that dots represent mean values, and intervals are +/- one standard deviation around mean.

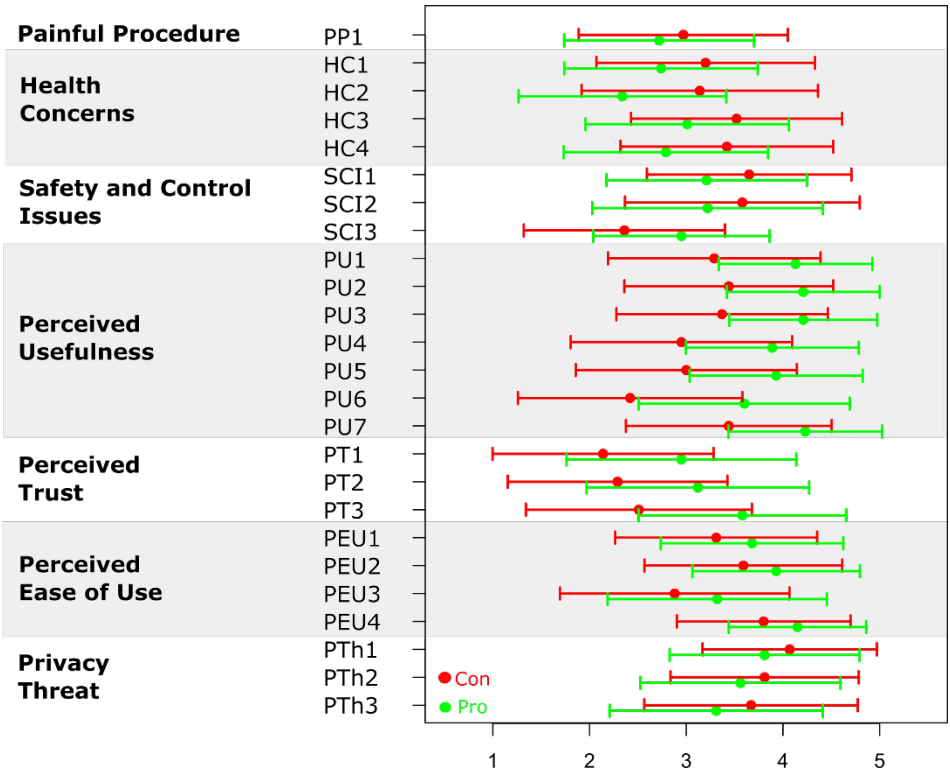

Figure 1: Error bars (mean values (dots) +/- one standard deviation) for attitudes toward MIs in groups pro and con for insertion of microchips for healthcare purposes

4 Conclusions

In the current situation with the Coronavirus COVID-19 pandemic, the popularity of MIs is rising. Due to the conflicting perception of MIs acceptance, various examples, discussions, as well as fake news, appear in the media. It has been reported that MIs were used for disaster victim identification in the tsunami of 2004 (Meyer et al., 2006). Kinkead (2014) reported the development of a contraceptive chip that could be activated using a wireless remote. On the other hand, public figures and their statements are being manipulated. According to Reuters (Reuters, 2020), the fake news of Bill Gates promoting MIs to fight coronavirus has been widely shared in social media. Several sources (Kinkead, 2014; McHugh et al., 2019) have been included in the misleading post about the "human-implantable capsules that have 'digital certificates' which can show who has been tested for the coronavirus".

Despite the abuse of information in media, the research on MIs and its usage for healthcare purposes continues, and advances in its research can be tracked in contemporary research articles. This research aimed to identify the difference in the perception of MIs adoption between groups of respondents pro and con of using MIs for healthcare purposes.

The highest percentage among respondents who showed a positive attitude toward the adoption of MIs was in Croatia and the lowest in Slovenia. Students and pupils were generally most willing to adopt MIs for healthcare purposes. The results show that statistically significant differences exist in 25 questionnaire items according to two groups of willingness to insert MIs. The highest statistically significant difference was identified in the item from the construct of the Perceived Usefulness of MIs. The lowest, although a statistically significant difference was identified in the item of the Privacy Threat construct. The only construct where no statistically significant differences between the two groups in its questionnaire items was the Privacy Right construct.

Based on the results, we can conclude that the general attitude towards the MIs differs between the people who are willing to implant MI for healthcare purposes, and the ones that are against it. Nevertheless, the issues which concern both groups are related to privacy. There are still some differences in the perception of privacy threat, whereas, for privacy rights, individuals have a similar opinion. We can conclude that the concerns of individuals about their privacy do not change even though they would be willing to implant a foreign body to enhance their health conditions. So although people agree with the use of MIs they expect some privacy issues remain.

5 Limitations and Future Research

Despite the large sample size, this research has some limitations. There was a small time gap of a few months between data collection in Slovenia, where the survey was first conducted, and other countries. This could influence the low willingness to adopt MIs in Slovenia. Second, the age diversity of participants in samples was different. In the Croatian sample, the majority of participants were students (56.9 %). This could affect the results, showing that Croatia has the highest percentage of respondents willing to adopt MIs.

In future research, a detailed comparison between countries is needed. We plan to compare the differences between countries based on the extended TAM model, although according to the first results and the abovementioned limitations, we could be forced to omit some data from the research. It is also planned to conduct the second iteration of the study and to compare the results before and after the COVID-19 pandemic, which influenced our daily routines and our perception the health and privacy.

Acknowledgments

This research was supported by the Slovenian Research Agency; Program No. P5-0018 – Decision Support Systems in Digital Business.

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Towards an Adapted Performance Measurement Model for health IT Enterprises

Mohammadi Réza[1] & Guerrero Isabelle[1]

[1] University of Montpellier, MRM Montpellier Research Management, Montpellier, France, e-mail: reza.mohammadi@umontpellier.fr, isabelle.guerrero@umontpellier.fr

Abstract With advances in technology and public access to health IT innovations, a prosperous market of e-health products and services is created which attracts a lot of investments. However, the success rate of so many startups is low and they do not survive in this competitive and highly-regulated market. There should be a strategic performance measurement model to guide health IT SMEs and startups because the models applied in other fields do not necessarily work to measure strategic performance of health IT enterprises.

By reviewing previous evaluations in the existing literature which have been applied to this field such as balanced scorecard and IS success model, this paper intends to develop a strategic performance model adaptable to the context and complications of health IT taking into account all the stakeholders involved.

Ključne besede: e-health, health IT, startup, evaluation, balanced scorecard, IS success model.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.43
ISBN 978-961-286-362-3

1 Introduction

The expansion of digital tools has created a transformation in healthcare systems (Agarwal, Gao, DesRoches, & Jha, 2010; Kohli & Tan, 2016; Tian et al., 2014) and public accessibility to internet and health IT systems has resulted in a great change in the way healthcare is delivered (Reardon & Davidson, 2007). The popularity of health applications for smartphones and connected objects is the reason for a great amount of investment in this dynamic sector. This trend has resulted in a huge investment in all health IT domains and creation of a prosperous market for SMEs and startups to commercialize their technological innovations in form of services and products (Kelley, Chiasson, Downey, & Pacaud, 2011; Reardon & Davidson, 2007).

Despite increasing prosperity of this market with investments in billions of dollars, there is no consent among public authorities, industrialists, representatives of patients and health experts about long-term success of enterprises involved in technologies of health (Hardiker & Grant, 2011; Kohli & Tan, 2016; Lapointe, Mignerat, & Vedel, 2011; Lemire, 2010). There are so many startups created each year in this competitive market with low survival rates of less than three years. The reason behind uncertainty of success could come from the multitude of stakeholders in the market of health technology with different and often contradictory requirements (Kohli & Tan, 2016) and the satisfaction of all different needs is very challenging. Due to these complications, the rate of success in this market is quite low and new startups and SMEs show up rapidly in the market and provide the patients with lots of applications, connected objects and services; whereas, with the same rapidity, they fade away and their products and services are abandoned (N. Connell & T. Young, 2007; Lorden, Coustasse, & Singh, 2008; Maiga & Jacobs, 2003).

Although developing a comprehensive and accurate assessment tool for health IT is important to have a good understanding of dynamics of market, the creation of this evaluation tool is very challenging. Firstly, the speed of change, evolution and transformation in health technology is very considerable. New SMEs and startups are constantly created and they immediately launch many health IT projects, products and interventions in the market (N. A. D. Connell & T. P. Young, 2007) which is too fast for researchers to evaluate their potential risks and dangers. Thus, a good measurement tool should be able to catch up with rapid evolution of

technological innovations in health. Secondly, a good evaluation tool should take all stakeholders into consideration. There are patients as the final users of the products and services along with their family members or caretakers who serve as a proxy (Kohli & Tan, 2016). Providers are another part of stakeholders including hospitals, physicians, and others who assist in direct patient care such as nurses. Purveyors, defined as custodians or keepers of health data (N. A. D. Connell & T. P. Young, 2007; Hardiker & Grant, 2011) constitute the third party of stakeholders. Providers and patients frequently serve as data source of purveyors and health IT startups and SMEs which deal with patient data are considered to be in this category. Each stakeholder has unique concerns and goals that are often in conflict with others. (Kohli & Tan, 2016).

2 Research Question

The importance of development of a comprehensive evaluation tool to assess the performance of enterprises which supply and launch health IT projects, objects and services is clear. Prior research includes several evaluations in health IT entrepreneurship, but none of the studies in existing literature provides a comprehensive model of performance measurement to take into account all stakeholders involved; therefore, the problematic of this research will be

How a strategic performance measurement could be created to evaluate the performance of health IT startups to take into account the context, complications and all involved stakeholders of health IT innovations, services and products?

Answering this question can contribute to the existing literature by creating a strategic performance measurement adaptable to health IT as a new emergent market with high failure rate of startups and SMEs.

3 Conceptual Background and Prior Research

Kaplan and Norton developed a comprehensive research model in 1990s which inherently makes use of strategic and operational considerations (Aidemark, 2010; Cleven, Mettler, Rohner, & Winter, 2016; R. S. Kaplan & Norton, 2004a). They argued that previous models were majorly based on financial accounting measures

and that caused an incomplete measurement of a business performance (Aidemark, 2010; Demartini & Trucco, 2017; R. S. Kaplan & Norton, 2004b; Messeghem, Bakkali, Sammut, & Swalhi, 2018; Schalm, 2008). They developed a multidimensional framework for measuring and managing organizational performance with comprehensive criteria to assess customer, internal process and learning. (R. S. Kaplan & Norton, 2004a, 2004b). In this line, BSC complements financial measures with operational measures on three dimensions: customer satisfaction, internal processes, and organization's innovation and learning (Chow, Ganulin, Haddad, & Williamson, 1998; Lorden et al., 2008; Naranjo-Gil, 2009). Therefore, BSC is considered a management system rather than a simple measurement system because it provides strategic guidance toward strategy implementation (R. S. Kaplan & Norton, 2004b; Naranjo-Gil, 2009; Wu & Chang, 2012; Zelman, Pink, & Matthias, 2003).

Having been largely applied and adapted in so many sectors, BSC gradually found its place in healthcare domain and it is now adopted by a broad range of health care organizations, including national health care organizations. (Gurd & Gao, 2008; Zelman et al., 2003). In spite of extensive applications of BSC in healthcare, there are complications to adapt BSC to this field. Firstly, BSC is a conceptual tool (Sasse, 2005), and its four perspectives are not always adaptable to all domains (M. Kaplan, 1988). In particular, due to unique characteristics of healthcare industry, BSC is difficult to get adapted to this field. (Gurd & Gao, 2008) For example, physicians, as major stakeholders, regard for themselves an absolute authority and superiority in the whole healthcare process (Lapointe et al., 2011; Zelman et al., 2003). The patients' access to health IT devices and services has empowered them to learn more about their health conditions, take more responsibilities to manage their health, communicate more effectively and efficiently between visits, and ultimately be an actor in the healthcare process (Kohli & Tan, 2016; Lemire, 2010). However, physicians tend to stick to traditional models which regard patients as subordinate and passive which makes it difficult to substitute the patient with customer in BSC. (Gurd & Gao, 2008; Niven, 2008).

Secondly, the most important defect of BSC is its framework which shows a cause-and-effect relationships among the four perspectives. (Cleven et al., 2016; Wu & Chang, 2012). In this hierarchical structure learning and growth perspective is defined in bottom and financial perspective at the top. This is not adapted to health

IT entrepreneurship because in this field the quality of care is as important as financial outcomes and they should be evaluated at the same level to measure performance. Additionally, different stakeholders are involved in health IT innovations with complicated relationships and sometimes contradictory needs and an antecedent to this model should be taken into account to discover these relationships.

Since the context of this study is health IT entrepreneurship, two constructs should be taken into consideration along with financial perspectives and both these constructs are ignored in BSC. Firstly, health results or *quality of care* as the context is healthcare and secondly, *IS effectiveness* as information technology is the core of health technological innovations. We intend to measure *IS effectiveness* construct (adopted from DeLone & McLean IS success model) as an antecedent of competitiveness and *quality of care* along with financial outcome at performance level. To do this, we should overcome the cause-and-effect nature of BSC with some modifications and our proposed research model is shown in Figure 1:

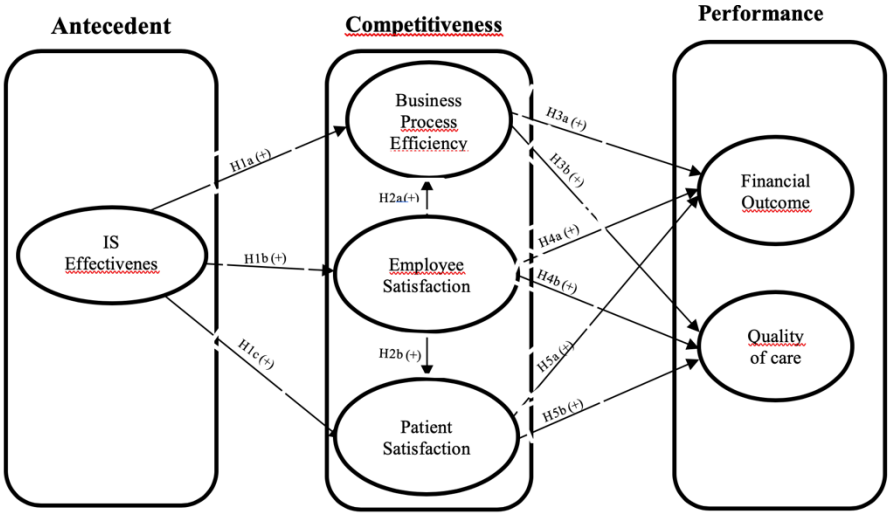

Figure 1: Proposed research model based on BSC

By changing cause-effect-relationship, this proposed model has divided the constructs into three levels of antecedents, competitiveness and performance.
At *competitiveness* level and its antecedent, **IS effectiveness** is supposed to be antecedent of competitiveness, giving health IT startups competitive advantage and value to increase their **patient** & **employee satisfaction** and improve their **business process efficiency**.

At *performance* level, the impact of each construct of competitiveness is going to be investigated firstly on **financial outcome** constructs, as a vital factor for investor satisfaction as well as startup survival. Secondly, the impact of each construct at *competitiveness* level will be investigated on the **quality of care** construct, as the main objective of health industry.

The definitions of all constructs are given in table 1. and regarding the complexity of stakeholders, each construct represents one party involved.

Table 1: Definitions of model constructs

Construct	Definition
IS effectiveness	**IS effectiveness** (ISE) construct measures the organizational and individual impact of information systems.
Patient Satisfaction	**Patient satisfaction** (PS) construct measures the degree to which patients and customers of health IT startups are satisfied, feel adequately treated, and do not complain.
Employee Satisfaction	**Employee Satisfaction** (ES) construct measures the degree to which a health IT startup's entire workforce is competent and at the same time, satisfied of its working conditions
Financial outcome	**Financial outcome** (FO) construct reflects the degree to which a health IT startup is able to generate revenues to finance future investments, make its process costs as low as possible and the overall cost level of its products and services competitive
Business process efficiency	**Business process efficiency** (BPE) construct evaluates the effectiveness of various processes for producing, commercializing and marketing of innovative products.
Quality of care	**Quality of care** (QC) construct is designed to measure concrete and direct outcomes of health IT innovations on health and well-being of user.

The following hypotheses are going to be tested in this research:

Hypothesis 1a: IS effectiveness is expected to have a positive effect on business process efficiency.

Hypothesis 1b: IS effectiveness is expected to have a positive effect on employee satisfaction.

Hypothesis 1c: IS effectiveness is expected to have a positive effect on patient satisfaction.

Hypothesis 2a: Employee satisfaction is expected to have a positive effect on business process efficiency.

Hypothesis 2b: Employee satisfaction is expected to have a positive effect on patient satisfaction.

Hypothesis 3a: Business process efficiency is expected to have a positive effect on financial outcome.

Hypothesis 3b: Business process efficiency is expected to have a positive effect on quality of care.

Hypothesis 4a: Employee satisfaction is expected to have a positive effect on financial outcome.

Hypothesis 4b: Employee satisfaction is expected to have a positive effect on quality of care.

Hypothesis 5a: Patient satisfaction is expected to have a positive effect on financial outcome.

Hypothesis 5b: Patient satisfaction is expected to have a positive effect on quality of care.

Study Context

Prior to this study, an observatory has been created to track more than 200 health IT enterprises in Occitanie region in South of France. (based on the definition of health IT given earlier). This observatory will serve as the fieldwork of this study and our hypotheses are going to be tested on this specific context; however, we target only health IT startups (based on the definition of startups given earlier) which constitute nearly 45% of Occitanie enterprises.

Among different types of enterprises in our fieldwork, we choose to concentrate on startups. The first reason for this choice is the great capacity of startups to be created quickly and use the capabilities of technological innovation to satisfy the needs of a growing market. (Beaulieu & Lehoux, 2017; Muhos, Saarela, Foit, & Rasochova, 2019; Wagrell & Baraldi, 2019). Startups, thanks to their structure, have a great potential to challenge the traditional healthcare service industry by introducing radical and sustainable innovations of technology. (Filson & Oweis, 2010; Muhos et al., 2019; Russell, 2015; Wagrell & Baraldi, 2019). The second reason for our choice of startups is obtaining a homogeneous sample to obtain generalizable results and thereby increase the external validity of this research.

Health IT startups of our fieldwork are involved in launching different technological innovations in form of health IT objects products and services which are categorized in appendix 1 as mobile applications, connected objects, clouds for health data, robots, online services like telemedicine. The users of the health IT startups are classified as all public (looking for improvement of health status and health indicators) general patients, patients of one specific disease, healthcare professionals, pharmacists, physicians, pharmaceutical laboratories and hospitals. As investors are important concerns of startups, we identified different investors at national and regional levels for health IT startups of Occitanie region in South of France such as Business Angels, the funds of capital risk, banks, venture capital mutual funds (FCPR) etc.

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SOCIAL COMMERCE ADOPTION: A CONSUMER'S PERSPECTIVE

FAIQ DEFIANDRY[1], SAVANID VATANASAKDAKUL[1] & CHADI AOUN[1]

[1] Carnegie Mellon University, Faculty of Information Systems, Doha, Qatar, e-mail: fdefiand@andrew.cmu.edu, savanid@cmu.edu, chadi@cmu.edu

Abstract Social Commerce is enabling new business models through social media platforms. The efficacy of such models has been investigated with a particular focus on benefits to businesses. Conversely, research into consumers in the social commerce interaction is yet to attract much interest. To address this limitation, this study investigates the factors affecting the use of social commerce among Indonesian retail consumers. Towards such objective, an integrated model is developed, extending The Unified Theory of Acceptance and Use of Technology through the inclusion of Task-Technology Fit and social value dimensions. This integrated model, therefore, spans technological, social and economic dimensions, hence providing a holistic framework for analyzing social commerce adoption among Indonesian retail consumers. This holds promising potential for theory and practice in the rapidly evolving field of social commerce.

Keywords: customer, Indonesia, IT adoption, social commerce, social media, UTAUT2.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.44
ISBN 978-961-286-362-3

1 Introduction

Social commerce refers to the use of web 2.0 technologies that support interactions in an online space, used to support a customer's experience in attaining services or products through the internet, using platforms such as Instagram or Facebook for commerce (Hajli, 2013). This can be seen as the evolution of e-commerce, by implementing the benefits of social media in traditional e-commerce (Wang, 2012), with notable benefits to in advertisement, communications, and customer support (Vázquez et al., 2003).

Social Commerce utilizes social media such as Instagram and Facebook to elevate the traditional e-commerce model from a 'product-oriented environment to a social and customer-centered one' (Huang, 2013). When compared with brick-and-mortar or traditional e-commerce models, the defining factor of social commerce is the lowering of social distance between vendors and consumers, transforming user behavior from passive consumers to active content contributors (Hajli 2012; 2013). For example, social commerce now allows users to directly message a business, request specific items or leave feedback. This provides benefits for both buyers and sellers in terms of facilitating transactions and building relationships.

While the rise of social commerce is anecdotally evident, relevant research into such context is still scarce, forming a key motivator for this study. Moreover, current research predominately adopts a business/organizational perspective, for instance, pointing to service quality, social support and corporate social responsibility (CSR) as success factors of social commerce (Maris, 2014). The buyer/consumer aspect of social commerce is yet to attract much attention. Consequently, addressing socio-cultural influences will provide a more holistic view of the intrinsic motivators to social commerce adoption from the consumer's perspective (Venkatesh et al., 2012; Zhou et al., 2013).

To address the knowledge gap, the paper proposes the following research question, empirically contextualized in the Indonesian socio-cultural milieu: 'What factors affect the consumers' adoption of social commerce in the Indonesian retail sector?'. Indonesia is selected as a case study due to a number of reasons. Indonesia is ranked the 5th on the most time spent on social media daily worldwide (Kemp, 2020). However, scholarly research on social commerce in Indonesia is limited to the

business perspective (Vatanasakdakul et al., 2019; Zhu et al. 2020). In answer to this question, we propose a research model that provides a holistic consideration of social commerce adoption from technological, social and economic perspectives.

2 Literature review: Social Commerce Adoption in Asia

Several studies have investigated the success factors of social commerce in Asia from an organizational perspective. First, social media engagement among organizations is expected to lead to a positive increase in purchases and brand recognition (Vatanasakdakul et al, 2019). Second, social media use could lead to cost reductions, with an estimated 48% of businesses in Asia being able to reduce costs using such media (Kryptonite Digital, 2014; Akman, 2017). Moreover, perceived service quality is a top contributor to social commerce success, yet it is highly influenced by the customer's trust (Dhiranty, 2017).

Yet, while benefits to the revenues and expenditures cycles are well-acknowledged and documented, building consumers' trust in social commerce is to be understood. These points to a research gap as numerous researches into social commerce adoption highlight the need for social commerce to maintain trust, accessibility and social support (Bain & Company, 2016; Blazquez et al., 2019). To address this, a thorough consideration of social dimensions needs to be incorporated into a technology adoption model, in order to ensure that such a model would holistically address technological, social and economic motivators (Zhou et al., 2013). Empirically, this study will focus on Indonesia as the focal point of data collection, due to the popularity of social media use and social commerce platforms (Tambunan et al., 2018).

From the aspect of its demographic, over 150 million of Indonesian residents are active on social media, with Instagram being the most popular (Tempo Indonesia, 2016; Greenhouse, 2019). Instagram users in Indonesia are generally financially well off. 69% of Instagram users in Indonesia had a college degree, with an income 1.5 times higher than the national average. 74.9% of Indonesian users made their purchases from shops on Instagram. (Tradegecko, 2015). This context, therefore, presents an effective opportunity for collecting empirical data, to test the relevant hypothesis and refine the research model.

3 Research Model

To address the research question, the study adopts the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) by Venkatesh et al. (2012), Task-Technology Fit model (Goodhue & Thompson, 1995) and social value factors (Zhou et al., 2013; Wang et al., 2016). These modules are then integrated leading to a theoretical model that consists of three conceptual dimensions, namely technological, social and economic. Figure 1 presents the proposed research model which provides a holistic view of social commerce adoption.

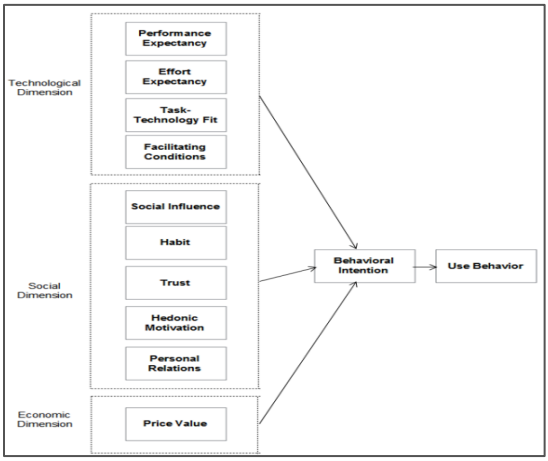

Figure 1: Research Model

The technology dimension examines consumer motivation when adopting social commerce relative to the merits the technology offers and the consumer's abilities to use it (Venkatesh et al., 2012). The technology dimension includes performance expectancy, effort expectancy, facilitating conditions from the UTAUT2 and task-technology fit models.

The social dimension examines the socio-cultural influences that can affect the consumer's willingness to adopt technology (Wang et al., 2016). The social dimension includes social influence, habit, and hedonic motivation from UTAUT2. Trust and personal relationships are introduced into the model in order to analyze

the extent in which they developed between consumers and vendors and how they influence social commerce adoption.

The economic dimension measures the consumer's perception on the financial aspects when adopting social commerce platforms. The factor in the economic dimension is price value (Venkatesh et al. 2012). It refers to the economic benefits or losses that the consumers may face when using social commerce (Venkatesh et al., 2012). The price value is suggested to be an important factor influencing social media adoption in Asia (Kryptonite Digital, 2014; Akman, 2017).

4 Conclusion and Future Research

This paper addresses a theoretical gap in social commerce adoption by proposing a holistic model that captures important technological, social and economic dimensions to investigate social commerce adoption among customers in Indonesia. The UTAUT2 model, TTF model, trust and personal relations were integrated to recreate the proposed model. Looking forward, quantitative empirical data is currently being collected through an online questionnaire using Qualtrics. Surveys were sent to 500 social commerce users in the Indonesian retail sector. Data collected will be compiled and analyzed using statistical software. Specifically, descriptive statistical analysis will be conducted using IBM SPSS while Partial Least Square Equation Modelling (PLS-SEM) will be conducted using SmartPLS software. The PLS approach was preferable for this study because it provides a better prediction capability and it is effective in the analysis of a high complexity model with small sample size compared to a large number of independent variables. In addition, it imposes no requirement of a normal distribution assumption which suits the nature of the data collected. It is hoped that the results will shed new light on factors motivating social commerce adoption among consumers – an area of theoretical and practical importance that is yet to attract research attention.

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The Shape of Participatory Platforms for Bottom-up Urbanism: A Definition and Study for Success Factors

Pascal Abel[1], Daniel Herrmann[2], Amelie Hinz[1] & Susanne Robra-Bissantz[1]

[1] Technische Universität Braunschweig, Chair of Information Management, Braunschweig, Germany, e-mail: p.abel@tu-braunschweig.de, a.hinz@tu-braunschweig.de, s.robra-bissantz@tu-braunschweig.de
[2] Technische Universität Braunschweig, Chair of Educational Sciences, Braunschweig, Germany, e-mail: d.herrmann@tu-braunschweig.de

Abstract Citizens in Europe and North America gather on digital platforms to shape their urban environment from the bottom-up. Digital platforms offer participatory mechanisms to involve citizens in different situations and higher or lower levels of control. Platforms with high levels of control allow citizens to implement their own projects. This offers self-governance and gives control to the citizens. Although a look into practice shows an increasing number of platforms, there is a research gap regarding such platforms and research addresses the need for evaluation of self-governance models in the context of smart cities. In the ongoing empirical study of 30 platforms, we extract success factors for the development and adaptation of these platforms for practitioners.

Keywords: participatory platforms, bottom-up urbanism, smart city, self-governance, shape.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.45
ISBN 978-961-286-362-3

1 Introduction

Smart city concepts focus on the improvement of quality of live as a goal with the use of information and communication technologies (ICT) in the urban environment (Kondepudi et al., 2014). There are two different concepts of the understanding to reach this goal: the top-down approach which is planned and executed by local governments and a bottom-up approach where citizens are the spring of the idea and care for the implementation by themselves (Breuer, Walravens, & Ballon, 2014).

Acting from the bottom: we see citizens around the world changing their urban space. They build old fridges into book-sharing shelves, organize local markets and revive an old building into a cinema. Those citizen-initiated activities are summarized under the term »bottom-up urbanism«. It is seen as an alternative to the top-down approach of planned environments (de Waal & de Lange, 2019) and we see the role of city planners changing: where planners previously developed projects for urban space, now the development of platforms for the engagement of the citizens is becoming a central task (Ertiö & Bhagwatwar, 2017). Local governments are acknowledging the citizen-driven initiatives (Fredericks, Hespanhol, Parker, Zhou, & Tomitsch, 2018) and research identifies it as a driver for urban innovation (Caragliu, Del Bo, & Nijkamp, 2011).

Successful smart city concepts use bottom-up elements as well as top-down elements (Shepard & Simeti, 2013). The usage of bottom-up participation elements can be seen as "logical extension of the democratic process in more local, direct, deliberative ways" (Brabham, 2009). In a shift towards the bottom-up we see a change towards a "smart city 2.0" in similarity of the rise of the web 2.0 concept (Trencher, 2019).

Arnstein's (1969) ladder of participation describes different levels of bottom-up participation. Even though Arnstein's concept is half a century old, it is still used as the evaluation standard for citizen participation (Collins & Ison, 2009). The ladder concept has been transformed and used in research for the conceptualization of different participation levels on digital platforms (Senbel & Church, 2011).

On the higher levels of participation future users are integrated into planning processes which helps to guarantee a widely acceptance of projects and citizen-involvement (Burby, 2003). To go further the approach of "[i]nterdisciplinary and participatory design collaborations seem[s] to be the best option for problem solving in a democratic society of the digital, postindustrial age" (Brabham, 2006). This means to bring the citizens together in experimental setting that leads to innovations (Anttiroiko, 2016) and to bring the smart city idea towards the centralization of the citizens in an inclusive, diverse manner and train ambiguity for future cities (Surowiecki, 2005).

On the highest level of participation citizens are in control of their actions which is known as self-governance in smart city research. Following Jacobs (1993) the right of citizens to actively change their conditions of everyday life is linked with their quality of life.

The empirical research of Gün et al. (2019) showed that "many of the platforms aimed at higher levels of design empowerment but failed to provide the required functionalities users need". We ask ourselves why we see so few platforms fulfilling the highest participation level.

In practice, bottom-up initiatives struggle to improve, maintain and fund their platforms (Abel, Stuwe, & Robra-Bissantz, 2019). Especially when it comes to platforms that target at high levels of participation, practitioners face the challenge of how they can successfully design such platforms.

According to Panopoulou et al. (2014) success factors cannot be generalized across different types of platforms since they are suspected to be linked to certain types of platforms. Therefore practitioners lack evidence-based recommendations in their journey to develop participatory platforms.

This study's outcome focuses on the following research question:
What success factors are important for participatory platforms that target at the highest level of participation in the context of bottom-up urbanism?

2 A definition of participatory platforms for bottom-up urbanism

In recent years there has been a broad interest in research on bottom-up urbanism activities (Kickert & Arefi, 2019). In recent empirical studies on participatory platforms in the urban context there has been a more general view of the nature of participatory platforms but they were not covering the highest level of participation (see Desouza and Bhagwatwar 2014; Falco and Kleinhans 2018) or investigating only 3 platforms from this level (see Gün et al. 2019).

When we take a look at the research, we find various components that lead to a definition. The main issue is that we have to acknowledge the concept of **bottom-up**. It is a change from asking the citizens towards what the citizen ask themselves. The citizens are in control of the process of their ideas and the implementation into the urban environment. It is "a radical repositioning of the designer, a shifting of power from the professional expert to the ordinary person" (Crawford, 2008). Their actions are recognized, supported or even invited by the government but not controlled.

The projects carried out by amateur designers with the character of **DIY in the public space** where citizens are the active part of the project implementation. But none of the projects is like another, there are various projects with different perspectives and goals (Kickert & Arefi, 2019).

The initiatives gather on digital platforms that offer various mechanisms for participation (Ertiö & Bhagwatwar, 2017). **On participatory platforms** it is up to the citizens to decide which participation mechanisms they want to use and therefore how deep they want to be involved.

The transparency that goes hand in hand with official digital platform excludes illegal or rebellious projects. On the one hand, the process is institutionalized and the actors made themselves visible. On the other hand, the projects gain a legitimation and the citizens act upon **self-governance** where they have the power for decision making which fulfills Arnstein's demand for citizen control.

3 Methodology & study design

Arnstein's ladder inspired the development of several frameworks for assessing eParticipation. In the selection and analysis of platforms we followed the frameworks from Tambouris et al. (2007) and Yusuf et al. (2019). Tambouris et al. (2007) present a framework that connects participation to electronic tools and technologies. Yusuf et al. (2019) proposed a framework especially for the smart city context. We executed the following steps (until step 3 so far):

(1) By searching scientific papers, websites, social media and getting suggestions from practitioners we constructed a database with 96 platform. (2) We identified 30 platforms which are offering self-governance within their set of participation mechanisms. These 30 platforms are located in Europe and Northern America which might be caused by the fact that bottom-up urbanism is a phenomenon of the global north (Kickert & Arefi, 2019). (3) A semi-structured interview was developed. We did not derive hypotheses about success factors from previous research according to the principle of theoretical openness, since success factors cannot be generalized across different types of platforms (Panopoulou et al., 2014). Therefore, the first part of the questionnaire included open-ended questions to gain in-depth understanding about practitioners' perspective on success factors. The second part of the questionnaire we asked the practitioners to rank the success derived from previews literature review (e.g. Gün et al., 2019). (4) We will analyze the qualitative data based on the grounded theory methodology. The grounded theory allows to discover "theories, concepts, hypotheses, and propositions directly from data, rather than from a priori assumptions, other research, or existing theoretical frameworks" (Taylor & Bogdan, 1984). Therefore it is ideal for discovering novel or unanticipated findings (Bryman, 1984; Creswell, 1994). According to (Urquhart, 2007), we used the preliminary literature review as orientation and not as defining framework. (5) We will compare the results of our qualitative data analysis and the evidence from the literature to explore the context dependency of success factors (theoretical grounding).

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FOCUS ON INTERACTION: APPLYING SERVICE-CENTRIC THEORIES IN IS

MANUEL GEIGER[1], SUSANNE ROBRA-BISSANTZ[1] & MICHAEL MEYER[1]

[1] Technische Universität Braunschweig, Carl-Friedrich-Gauß-Faculty, Department of Business Administration and Economics, Braunschweig, Germany, e-mail: m.geiger@tu-braunschweig.de, s.robra-bissantz@tu-braunschweig.de, m.meyer@tu-braunschweig.de

Abstract As Information Systems (IS) have already become a crucial part of everyday life, the need for new and innovative digital services for businesses is still growing. The combination of service-centric theories and IS has the potential to create appropriate services for the digital age. Despite the popularity of the service-centric theories, there are still literature gaps, especially in combination with IS. This paper aims to address these gaps by introducing an Interaction Model for designing new and improving existing services in the domain of IS. Interaction is within the service-centric perspectives an essential component to create value. At the same time, together with the technological progress, it is an essential part of IS research. Therefore, we propose a Value in Interaction Model consisting of three interconnected layers. On each of these layers, values are created. This approach is intended to make the service-centric theories from marketing more applicable to IS.

Keywords: interaction, service-dominant logic, service logic, service design, value creation, interaction design.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.46
ISBN 978-961-286-362-3

1 Introduction

In addition to Service Logic (SL) from the Nordic School of Marketing, Vargo and Lusch in particular have redefined the way of thinking and looking at the process of value generation in the service world (2004). The service dominant logic (S-D logic) is not only used in Marketing but also in Information Systems (IS), where it is particularly suitable for building theories (Barrett et al., 2015). This becomes more and more relevant as the advances in technology driven by the digital transformation lead to increased interaction, e. g. between suppliers and consumers (Yadav & Varadarajan, 2005), as digital networks enable and create new opportunities for communication between even more partners. Interaction is the glue that binds actors together (Fyrberg & Jüriado, 2009) in order to create value and thus, in our view, is essential for designing IS-supported services. But interaction in the context of service-centric theories as a central design element in current IS literature attracts too little attention (Brust et al., 2017). Particularly considering the background of continuous innovations in the IS field and the resulting new services and service possibilities, it is worth closing the existing research gap. For this purpose, we want to introduce a *Value in Interaction*. Interactions in the current discussion are mostly seen only as means to an end, for example as a basis for value co-creation (Breidbach & Maglio, 2016; Heinonen et al., 2010) or as a simple mechanism to facilitate exchange (Håkansson et al., 2010). In order to address this issue this contribution is structured as follows. After the conceptualizing of our research framework in the second chapter, we will shortly explain and discuss our *Value in Interaction Model* in Chapter 3. In chapter 4 we will explain the individual interrelationships of the model before concluding with a brief summary and outlook on further research in Chapter 5.

2 Conceptualizing the Research Framework

On the one hand, recent literature shows that research regarding the role of IS in service is up-to-date and highly relevant (Lim & Maglio, 2019; Ostrom et al., 2015) while at the same time technologies like while at the same time technologies like Internet of Things (IoT) or artificial intelligence (AI) demonstrate this relevance. The service-centric theories offer a possibility to create new knowledge and a better understanding of services based on IS (Barrett et al., 2015). Despite the popularity of S-D logic and SL there are still literature gaps, especially in combination with IS.

As Brust et al. (2017) were able to demonstrate through extensive literature analysis, the topics "Designing Service Experiences" and "New Service Development" were dealt with very little or not at all. Our paper aims to address this in combination with the focus on interactions by introducing a new interaction model for designing services in the domain of IS. The components of an interaction have their own value for the actors, which goes beyond increasing the density (best possible combination of resources for a particular situation) (Normann, 2001) or learning from previous interactions. In order to be able to work effectively with the IS, the interaction must be actively and individually designed to evoke these experiences. For this reason, we propose to introduce a *Value in Interaction*. Our research in progress paper is guided by Design Science Research (DSR) (Hevner et al., 2004). We are following the DSR research process by Peffers et al. (2007) consisting of 6 stages. (1) Identify Problem: The interaction between actors is essential for the design of innovative digital services. As mentioned, the analysis of Brust et al. (2017) showed a general research literature gap at the intersection of service-centric theories and IS research. As far as we know, there is no basic model that focuses on interaction as the basis for designing services. (2) Define solution objectives: Our solution objective is the introduction of a new service model for IS that explains the interaction during a service based on service-centric theories to create valuable interactions. (3) Design and development: Based on the service-oriented theories we suggest focussing on the interactions to be shaped by IS. Thus, we locate the task of the IS in influencing the layer **relationships** (see Chapter 4.1) and the **service** itself (see Chapter 4.3) with IS in such a way that the best possible result can be achieved from the actors perspective (later called **matching**; see Chapter 4.2). Therefore, we will propose the *Value in Interaction Model* consisting of three levels at the intersection of IS and service. Since this is a research in progress paper, we will initially discuss the first three steps of the process.

3 The Value in Interaction Model

The basis of any interaction is a link between actors, which exists in a common *Interaction Space* (Grönroos, 2006). It represents a potential provided by one actor, which another actor can perceive by "entering" this space. Such an *Interaction Space* can be the provision of an app (e.g. Nike+) or – more generally – an automated flow of information between actors (e.g. external monitoring of the heating system).

Through interactions in this *Interaction Space*, the actors have the opportunity to deal with the other actor and influence his or her behavior.

The proposed *Value in Interaction* arises within such an *Interaction Space* – independently for all participating actors. The value develops through and during the interaction itself. It unfolds its effect at the moment and thereby influences the further processes of value co-creation. It is thus the value of an interaction with another actor perceived by one actor. *Value in Interaction* is composed of three partial values: *Relationship Value*, *Matching Value* and the *Service Value* of the interaction itself. They emerge on three different layers: The *Relationship Layer*, the *Matching Layer* and the *Service Layer* (see Figure 1). In order to be able to design valuable interactions, to provide interactions with as much value as possible and to avoid useless or even negative interactions, actors must therefore be able to demonstrate competencies at all three layers. These are in particular collaboration and social competences (*Relationship Layer*), so-called matching competences (*Matching Layer*) and service competences (*Service Layer*).

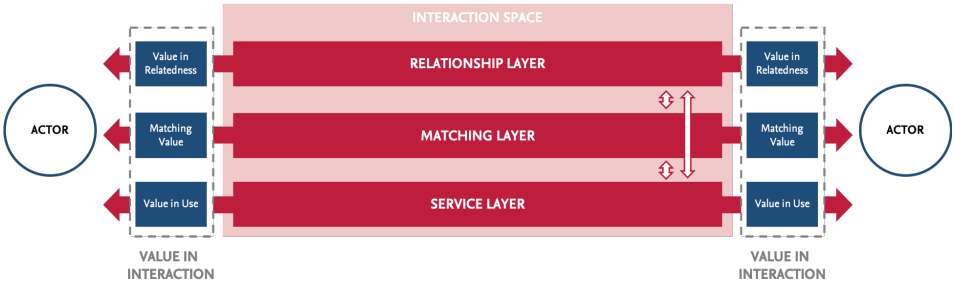

Figure 1: Value in Interaction Model.

However, the mere existence of an interaction does not always have to lead to co-creation with a positive value. Rather, it depends on the quality of the interaction (Fyrberg & Jüriado, 2009). An interaction characterized by mediocre or even negative aspects (lack of quality) will have negative effects on the value co-creation and the subsequent values. An actor should therefore always consciously design his interactions on all three layers.

Relationship Layer

The Relationship Layer deals with the emergence, influence and maintenance of the *Relationship Value*. It describes the quality of the relationship influenced by interactions between the relationship participants and can also be interpreted as a cumulative value across successive interactions (Gummesson, 1987). It results, among other things, from the social and relationship-relevant advantages that the actor claims, but also from the potential disadvantages (Cronin et al., 1997; Grewal et al., 1998). The *Relationship Value* has the possibility for both actors to increase and decrease during any interaction. Therefore, the aim of the actors is to expand or re-open the Interaction Space. Only then it can be filled with valuable interactions, so that a *Relationship Value* is created.

Matching Layer

The *Matching Value* is the ability of the two actors to anticipate the needs of the other and to "match" these with their own abilities and competencies. The actors thus select the appropriate resources and competencies for the existing needs of the other actor at (a) the *Relationship Layer*, (b) the *Service Layer*, but also (c) the right approach (e.g. inspiration, advice) for finding this appropriate resources and competences. The aim is to offer the best possible service (high density) with the appropriate interaction at the *Relationship Layer*. This is a prerequisite for the interaction to be continued, for it to function in the best possible way and for the value to be created at the *Service Layer*.

Service Layer

The *Service Value* arises directly within the interaction or during the simultaneous processes of the actors in the value co-creation. It describes how the interaction itself influences the actual service. It arises during the entire process of service provision itself but differs from the underlying objective of the service.

4 Effect of Value in Interaction

The three layers of the *Value in Interaction* and the resulting values are closely linked and influence each other (see Figure 1). Specifically, the *Relationship Value* has a direct influence on the *Matching Value*. If the *Relationship Value* is positive, which is equivalent to one or more previous, successful interactions at the *Relationship Layer*, the actors are willing to provide more detailed information. This contributes to a better matching and thus a higher *Matching Value*. If the service provider is able to create the right offer (high density) together with the customer in co-creation on the basis of the existing matching competences through appropriate interaction (e.g. inspiration, consultation), the requirements for value at the Service Layer are given. This in turn has a positive influence on the *Relationship Layer* through increased trust in the abilities and competencies of the other. If, on the other hand, the demanding actor notices that the competences at the *Matching Layer* of the service provider are not sufficient to achieve the best possible result (low density and low *Matching Value*), this will have a negative influence on the *Service Value* directly (*Matching Value* on the *Service Value*) and indirectly (*Matching Value* on the *Relationship Value* and the latter on the *Service Value*). In addition, the interactions on the *Service Layer* can on the one hand influence the *Relationship Value* positively or negatively and on the other hand be used to further adapt the service in the process to the needs of the actors (*Matching Layer*). If one assumes that interactions always take place when all actors can increase their *Service Value*, then the big difference between *Service Value* and *Relationship Value* is that the *Service Value* must differ meaningfully among the actors. This is because the competences and resources of one actor should each contribute to the *Service Value* of another. An actor thus experiences value precisely because it receives other competences and resources than he already has. The *Relationship Value*, on the other hand, can and must be comparable in many areas in the long term (Fyrberg and Jüriado, 2009).

5 Conclusion and Outlook

In the context of this paper we have pointed out that interaction is the glue between actors. We therefore propose to place interaction at the center of action and to introduce a *Value in Interaction*. This approach offers the opportunity to simplify the design of valuable interactions in IS by actively designing the individual levels of the model. With the *Value in Interaction Model*, we have made service-centric theories from

marketing more applicable to IS research. By this means we implemented Barrett's (2015) recommendation for the development of new theories in IS on the basis of these service-centric theories and will use them ourselves in the future to further simplify the way of designing IS-supported services. First, however, the empirical proof of the theoretically derived model must be provided by further research. Following the DSR research process by Peffers et al. (2007), we have to apply the model to existing services respectively to design several new services (Phase 4: demonstration). These services will be located in as many different contexts as possible. Furthermore, we will have to show the general accuracy of our model in an evaluation (Phase 5: evaluation). To achieve this, we need to make the individual layers and the values they create measurable.

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A Neurally Plausible Implementation of a Vowel Recognition System

Roelant Ossewaarde[1]

[1] HU University of Applied Science, Computer Science, Utrecht, The Netherlands,
e-mail: roelant.ossewaarde@hu.nl

Abstract We present research-in-progress aimed at developing a sensory recognition system with good performance in sparse training contexts. The system is a machine learning model, structured after a proposed neural architecture of early stage object recognition by humans. It stores representations in parallel systems that mimic associative and declarative memory systems. We present mathematical formulations of the underlying system of storage and apply this to the problem of vowel recognition by infants. The stored representation makes use of the distance between the formant frequencies of vowels, as analog magnitudes, rather than their absolute acoustic valuations. Our formulation allows for a learning strategy that is both neurally plausible and computationally tractable.The resulting system can be used in any environment that requires the system itself to recognize invariant properties of objects, visual or acoustic.

Keywords: object recognition, neural system, analog magnitude, vowel detection, machine learning.

DOI https://doi.org/10.18690/978-961-286-362-3.47
ISBN 978-961-286-362-3

1 Introduction

Neural networks (deep learning) represent the state of the art in current artificial intelligence applications. They dominate in the fields of visual and aural perception, even if some of their shortcomings have proven to be pervasive.

One of these shortcomings is that they require extensive training in order to accommodate variations of a stimulus. Perception AI systems typically have great difficulty detecting objects under transformations such as rotation, scaling and color changes, or of objects that are partially hidden or obscured by other objects. Human perception is hardly affected by either affine transformations or partial obscurity of objects.

Two of the architectural traits of the human brain that make it especially competent in fast object detection are the hierarchical architecture of the brain (Hawkins et al., 2019) and the specific division of labor between episodic and associative memory systems(Poggio & Anselmi, 2016). It is assumed that these systems build partial representations that are invariant for spatial transformations or partial obscurity ("invariants"). At different layers of the hierarchical structure, these objects are represented as imprecise approximations, of objects.

The overall goal is to develop a model that describes how infants learn to distinguish the sounds of their mother language(s) from foreign ones. A previous study (Vallabha et al., 2007) uses an Expectation-Maximization based approach (parametric) and a topography based approach (nonparametric) to learn the specific spaces of English and Japanese vowels. At the heart of their approach is the notion that some probability distribution is an adequate description of the amount of acoustic energy that characterizes each individual vowel. As long as the distributions are sufficiently distinct, software can learn to distinguish vowels after learning to decode the speech signal into an acoustic profile.

This study presents work-in-progress to develop the computational architecture for a neural perception system that mimics the way in which human brains can learn such distributional distinctions as invariant representations of sounds and then use transformations, in a similar way as affine transformations in the visual domain, to facilitate recognition.

Systems that employ invariants in general require far less training than conventional neural systems, and are especially robust to detect stimuli with representations that vary to a large degree (Dupoux, 2018).

1.1 The analog properties of auditory stimuli

The perception of sounds involves the determination of aspects of the stimulus. One aspect that is used to discriminate sounds is the distribution of energy over the spectrum of the frequencies that together form the sound. In particular vowel sounds are well distinguishable based on their differences in fundamental frequency (*F0*) and other local spectral peaks (formamts) (*F1* and *F2*). Vowel production shows variation between individual speakers. Vowel recognition is based on the relative difference between *F0*, *F1* and *F2* rather than on their absolute values.

The recognition of vowels requires the comparison between the magnitudes of the spectral energy at different formant positions. The neural system to represent magnitudes is usually modeled as a Analog Magnitude Accumulator (AM, Whalen et al., 1999) a process by which each events are enumerated or represented as an impulse of activation from the nervous system. The representation of a magnitude through this system is an approximation of the total number, with some margins for noise and error. Analog Magnitudes are subject to the so-called *magnitude* and *distance* effects (Dehaene, 1997; Flombaum et al., 2005).

It may be meaningful for a speaker to produce sounds in a particular part of their range, for example to indicate prominence, segmentation boundaries (Ladd, 2008) or information structure (Wennerstrom, 2001). When a speaker raises or lowers the pitch (*F0*), all other formants change as well. It is the distance between formants that determines which vowel is perceived. This distance must be large enough for speakers to be able to tell the formants apart. This is captured by the notion of "just-noticeable difference interval" (JNI), which has been studied for different kinds of stimuli. It is often assumed that the Weber-Fechner's law of psychophysics governs the function that predicts when two stimuli are distinct enough to be judged different. Applied to formants, the Weber-Fechner law expresses that our ability to detect a difference between two formant values depends on the base pitch height itself (Weber's law), and that the relationship between stimulus difference and discriminability is logarithmic (Fechner's law). Interpreted in this domain: the JNI is

greater for pitches higher in the spectrum than for pitches lower in the spectrum, and best plotted on a logarithmic scale.

Both human infants and human adults can generate numerosity estimates for up to three AM-sets in parallel (Halberda et al., 2006; Zosh et al., 2007), which at least in theory would enable an infant in the very earliest stage of language learning to be able to compare the quantities involved with vowel discrimination.

2 General architecture

As the general computational architecture to model the analog magnitudes necessary for vowel discrimination, we follow the general proposal of cortical organization detailed in Hawkins et al. (2019), the representational model of invariants by Poggio & Anselmi (2016) and the strategies for storing approximations from Leibo et al. (2015).

Hubel and Wiesel proposed a distinction between *simple* and *complex* cells (henceforth: S-, respectively C-cells) where C-cells pool S-cells in a network. One C-cell with its S-cells is a Hubel-Wiesel module (HW-module). The response of a C-cell that pools S-cells to a stimulus x is denoted as $\mu_k(x)$ for the k-th element of the signature of the concept. An HW-module features as a computational structure in most current theories of neural networks, including convolutional, HMAX and Nearest Neighbors networks. Concepts as stored in the brain are referred to as templates (τ_k) with as actual manifestations a set of k signatures.

2.1 Cortical columns store invariants

An HW-layer consists of one to many HW-modules, and the hierarchical organisation of HW-layers is called an HW-architecture. In the human cortex there are six of such layers, with the bottom one (denoted V1 for modules involved in visual perception) connected to the sensorimotor areas of the brain, and the highest one (IT) assumed to be the most abstract. Any form of cognition involves an interplay between the higher and the lower levels.

An invariant representation can be modeled as a particular activation pattern of different HW-modules. Invariant representations are encoded in the brain as early as in the lowest HW-layers. Because these layers are activated within the first 100ms of the ventral stream's exposure to a stimulus, feedback from the cortex cannot play a role yet in recognition. There simply isn't enough time for synapses to go roundtrip from the lowest to the highest level of the cortex in 100ms. We model in a computational way that early stage of recognition, assuming that the higher levels that do receive feedback from the top levels (or other HW-modules) are organized in a similar way.

Invariant representation for a stimulus at that low level requires the generation of representations of the perceived stimulus under a known set of transformations (in the auditory domain: pitch variations, voice quality, loudness, duration).

An HW-module may be considered a data structure that encodes a signature of τ_k. Under that assumption, it has a set of values and operations to access and update the atoms of data that the particular HW-module store. Learning means: a sequence of inserts or updates in the HW-module, given a particular activation caused by a stimulus. Each of the *K* HW-modules stores data *D* that corresponds with the signature of template τ_k.

In the brain, HW-modules are composed of neural cells, interconnected through dendrites that connect to axons. Computationally, if we denote the number of potential connections as *n*, a dendritic segment is represented as a binary vector $D = [b_0.., b_{n-1}]$ where a non- zero value b_i represents a synaptic connection to presynaptic cell *i* and $s = D$ indicates the number of synapses on that segment. At a given moment, 20-300 synapses (*s*) are typically active, over a much larger number of potential connections. A possible representation of the synaptic configuration of HW-modules is by sparse distributed representations (Ahmad & Hawkins, 2016).

If an HW-module is seen as a data storage unit, its insert and access operations can be given as in Eqs. 1 and 2, (cf. Leibo et al., 2015). Object categorization is then done by finding the μ_k that minimizes the loss function.

$$\text{INSERT}(D_k, t) : D_k \leftarrow D_k \cup \{t\}. \quad (1)$$

$$\text{QUERY}(D_k, t) : \mu_k(x) \leftarrow \max \langle x, t \rangle \quad (2)$$

Biologically, the INSERT-operation of Eq. 1 is implausible. Brains do not directly store information as a database does, but rather, we argue, as an approximation of the strength of an aspect of the stimulus. In this view, the brain stores an approximation of properties such as size, length, temporal structure etc. as the components of an invariant representation of objects in the real world. Rather than storing a discrete number, an analog magnitude is stored, in the form of a subpart of the joint activation of a subpart of a cortical column.

In our computational model, the formulation of the INSERT operation as proposed by Leibo et al. (2015) is used, which formulates two separate operations.

In the first INSERT strategy, the best rank-r approximation of a matrix is computed. The set of templates (the invariant properties of vowel sounds) is first expressed as a matrix (T_k), which represents the specific activation patterns of HW-modules. The matrix is then reduced using Singular Value Decomposition (SVD) and Principal Component Analysis (PCA). The INSERT operation is then defined as in Eq. 3, the concatenation of T_k and new information (t) resulting from a stimulus.

The second INSERT strategy uses random projections (Bingham & Mannila, 2001) (cf. Eq.4). A random projection is a projection of matrix X (with dimensions $n \times m$) to X' (with dimensions $n \times o$, where

$o < m$ per the Johnson-Lindenstrauss lemma) by the transform over a matrix with random values. Dimensionality reduction using random projections is computationally less intensive but does not result in an outcome with correlated candidates. Hence, storage is quicker but the relations between templates necessary for invariance are lost.

INSERT(Dk, t): Dk $\leftarrow$[Tk | t] V' with $U'\Sigma'V'$ = [Tk | t] (3)

INSERT(Dk, t): Dk $\leftarrow$ [Tk | t] [R | r] with $U'\Sigma'V'$ = [Tk | t]

where r = random vector s. th. [R|r] is orthogonal (4)

The two INSERT operations can account for two different ways of storing representations. The first INSERT (dimensionality reduction through SVD/PCA) is slower for insertions but does retain any correlations to other templates and is thus a good candidate for the type of associative memory that is required for invariant representation in the cortical areas. The second INSERT works without reference to any other template, and is computationally simpler - the biological counterpart could be the hippocampus which stores episodic memory. Because this project is limited to the earliest stages of cortical processing, before any synaptic pathway can be excited or inhibited for feedback, the first INSERT (Eq. 3) is the only considered for implementation.

2.2 Acquisition of priors

In a machine learning system, invariance to auditory or visual translations (such as scale, du- ration, pitch height) can be built up by simply memorizing examples. The core of the computational model is to construct a system that does not rely on such extensive memorization. The algorithm we use has been adapted from that used for visual processing as proposed by Poggio and Anselmi (2016):

1. Developmental stage
    a. For each of K isolated templates (cf. τk), memorize a sequence of Λ of |G| frames corresponding to the sound pattern transformations (g_i = 1, ...,|G|). This may include the absence of change which characterizes prolonged vowel duration. The sequence of frames is observed over some time interval.
    b. Repeat for each of K templates.

2. Online determination of invariant signature for a single stimulus from a new object.
    a. For each t_k compute the dot product of the stimulus with each of the |G| transformations in Λ_g.
    b. For each k compute a probability distribution of the resulting values.
    c. The signature is the set of *K* cumulative distributions. It is stored using the INSERT operations defined in Section 2.1.

A template stores the approximate distance between formants and their values. When a stimulus has duration, such as a vowel sound, the transformations learned in the develop- mental stage may be the absence of change. This approach captures both the invariance (by applying known transformations in a generative way) and the analog nature (by using dimensionality reduction) of approximation of the transformation results. In terms of a vowel sound, JNI distances between *F0*, F1, etc. are computed in the generative step, but acceptable deviations from these are accounted for by the proposed approximated storage. A logical extension of the generative part is by positing a two-stage approach, in which the first stage ensures that a final signature is composed by HW-modules by pooling over invariant signatures, and the second stage permits specialized transformations that are object specific.

3 Results

The presented approach is implemented in R. Neural activations are inserted after PCA, modeled as a binary sparse distributed representation (SDR). The advantage of such a distributed representation is that synaptic pathways across HW-modules can be encoded without positing a separate neural level for each different HW-layer. The SVD/PCA models magnitudes and their analog nature.

Because the implementation follows the HW-architecture as discussed in Section 2, it mirrors a biologically plausible neural architecture for perception learning. We are currently in the process of extensive experimentation with real data.

The INSERT-operations using matrices and dimension reduction techniques allow for a plausible way to model the approximateness of properties of concepts. Learning at INSERT takes place by application of Oja's rule, which is a generalized form of PCA using Hebbian learning (Oja, 1982).

Although auditory perception is a relatively straightforward task, the implementation can easily be adapted to other problems that are typically a challenge for training-heavy Machine Learning. Such tasks are for example the fast recognition of previously unseen objects or of objects that may be presented after spatial transformations such as scaling, rotation.

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#SAFESEX – THE EFFECTIVENESS OF SOCIAL MEDIA INFLUENCERS AS AMBASSADORS OF SEXUAL HEALTH BEHAVIOR

LOES JANSSEN[1], ALEXANDER P. SCHOUTEN[1] &
EMMELYN A. J. CROES[1]

[1] Tilburg University, Tilburg center for Cognition and Communication, Tilburg School of Humanities and Digital Sciences, Tilburg, the Netherlands,
e-mail: l.janssen@tilburguniversity.edu, a.p.schouten@tilburguniversity.edu, e.a.j.croes@tilburguniversity.edu

Abstract Institutions for health promotion are increasingly investing in social media campaigns. As an example, the Dutch institution for sexual health, Soa Aids Nederland, regularly collaborates with 'social media influencers' to inform and advise young adults about safe sex in YouTube vlogs. Based on the commercial success of influencer recommendations, integrating health messages in entertaining video content seems a promising instrument to stimulate young adults' health behavior. However, no research to date has investigated this phenomenon. The present research presents a content analysis investigating which strategies (e.g., humor and self-disclosure) influencers use in vlogs to communicate with a young adult audience about sexual health behavior, and how these relate to the engagement that the vlogs generate. Engagement with social media (e.g., views, likes, and comments) serves as an indicator for attitudinal and behavioral effects, and this study provides a crucial first step for systematically investigating the effectiveness of influencer-endorsed health information.

Keywords: social media, influencer, sexual health, content analysis, vlog, digital health communication

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.48
ISBN 978-961-286-362-3

1 Introduction

The digital transformation of society has changed the way in which health organizations are reaching out to their target groups. To reach young adults (18-25 yrs.), institutions for health promotion increasingly invest in health interventions via social media such as YouTube and Instagram. As a leading example, the Dutch institution for sexual health, Soa Aids Nederland, regularly collaborates with 'social media influencers'. In online prevention campaigns (e.g., see 'Britt Talk' on Sense.info), these youngsters who share their daily lives and interests with a large peer audience on social media, mostly in the form of short video diaries ('vlogs'), provide advice about topics such as contraceptives to prevent sexually transmitted infections (STIs) and hiv.

Although health organizations like Soa Aids Nederland have been investing in influencer campaigns since 2011, it remains unclear whether social media influencers are an effective instrument to inform and advise a young adult audience about health topics like safe sex. Whereas a growing body of research suggests that influencer recommendations have a significant impact on young adults' attitudes and behavior, these investigations have all been performed in the domain of influencer marketing, focusing on brand attitudes and purchase intentions (e.g., Chapple & Cownie, 2017; Djafarova & Rushworth, 2017; Schouten, Janssen, & Verspaget, 2019). To the knowledge of the authors, no academic research to date has investigated whether the popularity of influencer-generated content, which is attributed to its relatability and trustworthiness, can be effectively harnessed to stimulate young adults' health behavior.

To shed more light on the effectiveness of social media influencers as ambassadors of health behavior, and specifically sexual health behavior, the present research project of Tilburg University in collaboration with Soa Aids Nederland investigates the following research questions:

RQ1: Which strategies are currently being used in influencer vlogs to communicate with a young adult audience about sexual health behavior?

RQ2: How do the employed communication strategies and characteristics of the influencers relate to generated audience engagement (e.g., views, likes, and comments)?

By answering these initial questions, the project aims to provide input for systematically testing the impact of influencer, message, and receiver characteristics that may contribute to the effectiveness of influencer-endorsed health information, and the processes via which these effects occur. In addition, the project aims to contribute to the development of an advisory instrument for health promoting organizations on how to effectively involve social media influencers in future health campaigns.

2 Theoretical framework

In the Netherlands, yearly tens of thousands of individuals are diagnosed with an STI (such as chlamydia and gonorrhea), and over 800 people get infected with hiv (RIVM, 2018; Soa Aids Nederland, 2019). Most STIs are contracted by young adults between the age of 18 and 25 years, who are discovering their first sexual relationships (RIVM, 2018). Ever since 2012, condom use among Dutch youngsters is declining, leading to increased risk of contracting STIs, increased chance of unwanted pregnancy (Seks onder je 25e, 2017), and a need to invest in targeted health interventions.

Acknowledging young adults' fervent use of digital technology, Soa Aids Nederland invests in online prevention campaigns to inform and advise about sexual health behavior. Via their online platform Sense.info (in collaboration with Rutgers for sexual and reproductive health and rights, the Public Health Service, and the Ministry of Health, Welfare and Sport), they try to involve and stimulate conversation about sexual health topics, such as using contraceptives and getting STI and hiv check-ups. To create content for the Sense social media channels (YouTube, Instagram, Facebook, and Snapchat), Soa Aids Nederland regularly collaborates with social media influencers.

Social media influencers are creative content creators who commonly operate within a specific 'niche', such as food, fitness, beauty, or gaming. Influencers use social media to strategically construct an authentic personal brand through blogging or vlogging about their lives and thereby building a large fan base (Khamis, Ang, & Welling, 2017). Given the popularity of social media platforms like Instagram, it is not surprising that social influencers have become the new opinion leaders among young people, and marketers have embraced them as spokespersons for their brands, endorsing an endless range of products and services (Lin, Bruning, & Swarna, 2018).

Influencers are perceived as authentic and accessible 'superpeers' that young adults are able to identify with and whose lifestyles they aspire (Chapple & Cownie, 2017; Djafarova & Rushworth, 2017). Youngsters are more likely to trust the information and advice that is provided by their peers, as compared to company-provided information (Colliander & Dahlén, 2011), and both credibility and identification appear to play an important role in influencer endorsement effects (Lou & Yuan, 2019; Schouten et al., 2019). By stimulating interaction with their followers and building so-called parasocial relationships, influencers are able to generate online (and offline) engagement around a topic or brand (Djafarova & Rushworth, 2017).

Influencers thus seem to be a powerful persuasive instrument, and just as commercial marketers, health communication professionals have tried to harness influencers' unique characteristics to promote healthy behaviors, such as practicing safe sex. Previous campaigns and research have demonstrated that influencers can activate young adults to discuss topics like sex, STIs and hiv in an online environment, share information among their online networks, and break taboos surrounding these topics (Lutkenhaus, Jansz, & Bouman, 2019; Wu et al., 2019). However, it remains unclear to what extent influencer-endorsed health information on social media can actually contribute to more healthy attitudes and behavior, and via which processes these effects occur. The present research project addresses both a scientific, as well as a practical need for knowledge on how these digital health interventions can be most effectively used to stimulate young adults to take care of their own sexual well-being.

3 The present research

To answer our initial research questions as part of a larger research project, we are currently conducting a content analysis on a corpus of 200 Dutch, UK, and US YouTube influencer vlogs about sexual health behavior. With this content analysis we aim to identify which communication strategies the influencers use to inform, advise and entertain their audience, and how these strategies as well as their personal characteristics relate to the online engagement that the vlogs generate. Engagement with social media is a crucial first step affecting audience's attitudes and behaviors and thus serves as an indicator for the effectiveness of influencer-endorsed health information in social media posts (Kabadayi & Price, 2014).

The codebook is currently being developed, starting from a list of communication strategies based on literature on online health communication, influencer marketing, persuasive communication, and self-presentation on social media. Specifically, in the content analysis we will focus on the persuasive appeal strategies used in the message (e.g., humor; Buijzen & Valkenburg, 2009; threat; Paek, Kim, & Hove, 2010; argumentation type; Cornelis, Cauberghe, & De Pelsmacker, 2013), the self-presentation strategies that the influencers employ (e.g., self-disclosure; Utz, 2015), the narrative content of the vlog (e.g., message integration, interactivity; Shen, Sheer & Li, 2015), and the technical and visual features of the vlog (e.g., camera angles; image quality; Molyneaux, Gibson, O'Donnell, & Singer, 2007). In addition, we will code influencer characteristics (e.g., age, gender, lifestyle, popularity), and to measure engagement, we will code the number of views, likes, dislikes, and comments in response to the vlogs. Moreover, we will analyze the content of the comments: we employ sentiment analysis to get an indication of a viewer's attitude towards the topic discussed in the vlog, and we use automated content analysis to measure behavioral intention (i.e., people acknowledging condom use).

At the BLED conference, we will present the results of our content analysis and show to what extent specific strategies and influencer characteristics are related to engagement. Based on the content analysis, we aim to identify the communication strategies that are most effective in promoting health behavior among young adults. The effects of these strategies on attitudes and behavior will be subsequently tested among a large sample of young adults.

Acknowledgements

This research project is funded by the Dutch Research Council (NWO) in the program Creative Industry – Knowledge Innovation Mapping (KIEM).

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Platformization of Data Sharing: Multi-Party Computation (MPC) as Control Mechanism and its Effect on Firms' Participation in Data Sharing via Data Marketplaces

Wirawan Agahari[1]

[1] Delft University of Technology, Faculty of Technology, Policy and Management, Delft, the Netherlands, e-mail: w.agahari@tudelft.nl

Abstract Data sharing facilitated by data marketplaces enable companies to generate meaningful insights and discover new opportunities. However, enterprises are reluctant to share data over platforms due to lack of trust, fear of losing control over data and concerns regarding privacy violations. Multi-party computation (MPC) is a cryptographic technique that enables joint data analyses by multiple parties while retaining data secrecy. Despite the potential of MPC, its meaning in data marketplaces setting and how MPC change firms' behavior towards data sharing is not yet researched. This research aims to explain why and how MPC could enable platform control and affect firms' participation in data sharing via data marketplaces. To do so, we will employ a mixed-method research design by combining semi-structured interviews with actors in the mobility domain and quantitative experiments using a mockup of MPC-enabled data marketplaces. Our initial findings revealed various barriers and incentives for firms in sharing their data. We expect our research to become a foundation for future research in the emerging phenomenon of platformization of data sharing via data marketplaces and the key role of MPC in enabling the data economy.

Keywords: data marketplaces, multi-party computation, data sharing, platform control, data economy.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.49
ISBN 978-961-286-362-3

1 Introduction

In this digital era, technological advancement makes it possible to generate an enormous amount of data via sensors and smart devices. As a result, data is viewed as one of the most important resources in the world (The Economist, 2017). However, most of the data collected by firms are left unused, which poses a significant challenge in realizing the so-called "data economy" vision (Green, 2015; Manyika, 2015).

Data marketplaces could bridge this gap by facilitating data sharing and trading between companies to generate meaningful insights and stimulate innovation (Koutroumpis, Leiponen, & Thomas, 2017; van den Broek & van Veenstra, 2018; Virkar, Pereira, & Vignoli, 2019). Such platforms enable its participants to store, maintain, access and trade data from various sources based on different licensing models (Schomm, Stahl, & Vossen, 2013; Stahl, Schomm, Vossen, & Vomfell, 2016). On top of that, data marketplaces also offer complementary applications and services such as data visualizations, data valuation, and data analytics (Schreieck, Hein, Wiesche, & Krcmar, 2018; Spiekermann, 2019; van den Broek & van Veenstra, 2018). However, there are various barriers for enterprises to share data with other actors, such as lack of trust (Arnaut, Pont, Scaria, Berghmans, & Leconte, 2018; Dahlberg & Nokkala, 2019; Kembro, Näslund, & Olhager, 2017), fear of losing control over sensitive data that could benefit competitors (Jarman, Luna-Reyes, & Zhang, 2016; Klein & Verhulst, 2017) and concerns over privacy violations (Khurana, Mishra, & Singh, 2011; Sayogo et al., 2014).

Novel privacy-preserving technologies may overcome risks of data sharing in data marketplaces. One class of these is multi-party computation (MPC), which enables multiple parties to jointly analyze data while retaining the secrecy of the data (Choi & Butler, 2019; Roman & Vu, 2018; Zhao et al., 2019). With MPC, the security and confidentiality of the data can be guaranteed since the computation results in an aggregated output while not disclosing the input provided by a single party (Bestavros, Lapets, & Varia, 2017; Zhao et al., 2019). However, real-life deployments of MPC are still lacking, and even more limited in data marketplaces context. Hence, there is still little knowledge regarding the meaning of MPC in the data marketplaces domain, as well as its influence on firms' willingness to share data.

In the IS literature, data sharing between organizations has been studied prominently since the emergence of Electronic Data Interchange (EDI) and Inter-Organizational Systems (IOS), with the main focus on the antecedents of data sharing between two partners with a clear usage context (Elgarah et al., 2005; Narayanan, Marucheck, & Handfield, 2009; Praditya, Janssen, & Sulastri, 2017). Important factors in this setting include security (e.g. de Prieëlle, de Reuver, & Rezaei, 2020; Fu, Chang, Ku, Chang, & Huang, 2014; Lippert & Govindarajulu, 2006; Sun, Cegielski, Jia, & Hall, 2018) and trust (e.g. Asare, Brashear-Alejandro, & Kang, 2016; de Prieëlle et al., 2020; Pavlou & Gefen, 2004; Sila, 2013). However, the new phenomenon of data marketplaces is challenging the current understanding of data sharing. Specifically, data marketplaces allow data sharing in a complex ecosystem with an unbounded range of participants, which increases uncertainty and causes data providers to perceived a lack of control over their data (Spiekermann, 2019). Furthermore, the introduction of MPC also challenges the current understanding of why companies share data since it enables a new approach in the form of aggregated data sharing and the sharing of "data insights" (Bestavros et al., 2017; Elliott & Quest, 2020; Lapets et al., 2018). These differences thus require new studies on how governance aspects of data sharing through platforms, particularly platform control (e.g. Tiwana, Konsynski, & Bush, 2010), affect firms' participation in data sharing facilitated by data marketplaces.

This research aims to understand why and how MPC could realize platform control and affect firms' intention to share data in data marketplaces. Based on this objective, we propose our main research question as to the following:

How does platform control, as realized through secure multi-party computation (MPC), incentivize companies to participate in data sharing activities facilitated by data marketplaces?

We divide our main question into three sub-questions to guide our research further:

1. How does MPC enable platform control in the context of data marketplaces?
2. What are the effects of MPC, in which it enables platform control, on firms' willingness to share data via data marketplaces?

3. What is the role of trust and perceived risk towards data consumers in the relationship between MPC as platform control and firms' willingness to share data via data marketplaces?

To answer these questions and ultimately fulfill the research objective, we will focus on the mobility sector as our domain under study and follow a mixed-method research design, combining qualitative and quantitative research approaches (Venkatesh, Brown, & Bala, 2013).

The remainder of this paper is structured as follows: In section 2, we elaborate on MPC, control mechanisms of digital platforms as well as trust and perceived risk as background knowledge for this research. Next, section 3 presents our approach to answer the main question and fulfill the research objective, followed by a brief discussion on preliminary findings in section 4. Finally, section 5 outlines the expected contributions of our research.

2 Background

2.1 Secure MPC

MPC is a cryptographic technique where two or more parties perform a joint computation that results in a meaningful output without disclosing the input provided by either party (Bestavros et al., 2017; Choi & Butler, 2019; Zhao et al., 2019). Conceptually, MPC makes it possible to balance the tension between sharing information to create value and protecting information as a competitive advantage, which often emerges in the context of cooperating competitors (e.g. Gast, Gundolf, Harms, & Collado, 2019). A typical example to illustrate MPC is the millionaire's problem (Yao, 1982), a secure comparison function to determine which one of two millionaires is richest without revealing the net worth to each other. While there are some real-life applications of MPC, such as auction-based pricing (Bogetoft et al., 2009) and gender wage gap analysis (Lapets et al., 2018), its application within the context of data marketplaces is lacking (exception: Roman & Vu (2018)).

In this research, we conceptualize MPC as a means to exercise control in data marketplaces. With MPC, it is possible to (1) share data without having to store it centrally (i.e. distributed/decentralized data sharing); and (2) sharing aggregate data/data insights (i.e. not necessary to exchange individual data). In this way, data providers might be able to regain control over data, which could potentially increase trust and reduce perceived risks while exchanging data in a non-predefined scenario via data marketplaces. This approach is in line with previous research on data marketplaces that points out the importance of data providers to keep control over their data (Otto & Jarke, 2019). Therefore, MPC could serve as an appropriate solution for this matter because it might change the way data is stored and processed, which ultimately allows the securing of the data.

2.2 Control Mechanisms of Digital Platforms

Digital platforms are a unique type of digital artifacts that comprise of transaction and innovation capabilities (Cusumano, Gawer, & Yoffie, 2019; de Reuver, Sørensen, & Basole, 2018; Gawer, 2014). Transaction capabilities mean that digital platforms mediate different user groups (Hagiu & Wright, 2015), resulting in network effects (Katz & Shapiro, 1985). Meanwhile, innovation capabilities are related to the extensibility of digital platforms, in which they provide technological building blocks (e.g. Android or Apple iOS) that allow third-parties to develop complementary modules (e.g. mobile apps) (Tiwana et al., 2010).

Control mechanisms are one of the essential governance mechanisms for digital platforms to be successful in the market (Schreieck, Wiesche, & Krcmar, 2016). It is generally a set of approaches employed by a platform owner to ensure that participants behave as desired (Tiwana et al., 2010). By exercising platform control via rules, regulations, and incentives, platform participants are enforced to behave consistently with the objective of the platform owner (Goldbach, Benlian, & Buxmann, 2018; Tiwana, 2013).

Control mechanisms comprise two distinct types, namely formal and informal control (Goldbach et al., 2018; Mukhopadhyay, de Reuver, & Bouwman, 2016; Tiwana, 2013). To exercise formal control, platform owners may choose to establish selection criteria (i.e. input control), rules/procedures (i.e. process control) and/or

target performance (i.e. output control). Meanwhile, two categories of informal control can be identified: self-control (i.e. capacity building for self-regulation) and relation-al/clan control (i.e. shared norm and values) (Goldbach et al., 2018; Mukhopadhyay et al., 2016; Tiwana, 2013).

MPC offers a new approach to exercising control in the form of 'algorithmic control.' The computation will be performed automatically and resulted in aggregated insights that restrict the way data consumers utilize the data. In this way, MPC would allow automated process control without any human involvement. Nevertheless, we intend to explore MPC as complementary to existing control mechanisms in data marketplaces and not to replace human control with automation fully.

2.3 Trust and Perceived Risk

Trust plays a vital role as a prerequisite of data sharing and trading in data marketplaces (Richter & Slowinski, 2019; Spiekermann, 2019). Maintaining trust in this setting is challenging since the value of the data is difficult to understand without disclosing it, yet the value may decrease after that because of its non-rivalrous nature (Koutroumpis et al., 2017). Here, we focus on the trust of data providers' towards data consumers. In this way, we can explore possibilities to incentivize data providers so that they have more willingness to share data via data marketplaces.

Our emphasis is on trust at the inter-organizational level (Pavlou, 2002), which comprises two dimensions: credibility (i.e. trustor believes in the trustee in performing effective and reliable transaction) and benevolence (i.e. trustor believes that trustee's motives are beneficial to them). We also put specific attention on data providers' trust in a networked setting (one-to-many), where data providers interact with a wide range of data consumers in data marketplaces. Following Pavlou and Ge-fen (2004), we conceptualize trust as the subjective belief of data providers that online transactions with data consumers in data marketplaces will occur in a manner that consistent with data providers' expectations of trustworthy behavior.

Trust is often associated with perceived risk, especially while transacting in online marketplaces (Nicolaou & McKnight, 2006; Pavlou, 2002; Pavlou & Gefen, 2004). An example of risk in the context of data sharing via data marketplaces includes a risk that competitors might gain an advantage from the data shared by data providers (Spiekermann, 2019). We look into perceived risk from the perspective of data providers and extending the definition by Pavlou and Gefen (2004) to the context of data marketplaces. Here, we describe data providers' perceived risk as data providers' perception that there is a likelihood of suffering a loss when performing transactions with data consumers in data marketplaces.

2.4. Initial Research Model

Building on the theoretical background of MPC, platform control, trust, and perceived risk, we develop an initial research model of firms' behavior towards data sharing in data marketplaces. We illustrate this model in Figure 1.

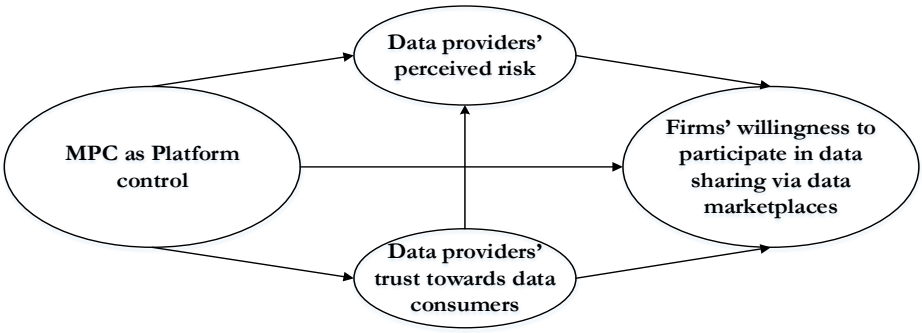

Figure 1: Initial research model

First, we conceptualize MPC as an instance of platform control that may affect firms' willingness to share data via data marketplaces. Then, we expect that this causality is mediated by trust and perceived risk of data providers in sharing data with data consumers in data marketplaces. Lastly, from data providers' perspective, higher trust towards data consumers may reduce the perceived risk of participation in data sharing via data marketplaces. It should be noted that we cannot establish clear hypotheses yet since the notion of MPC in data marketplaces is still very new. We

will specify each concept and refine our model during the qualitative study and test the model via quantitative study (see section 3).

3 Methodology

This research will adopt a mixed methods research design (Venkatesh et al., 2013), combining quantitative and qualitative research approaches. This approach is appropriate because (1) data marketplaces are hardly studied from platform perspectives, and (2) there is a lack of knowledge on the meaning of MPC in data marketplaces context. Therefore, we first need to conduct a qualitative study to contextualize MPC and platform control into data marketplaces setting. The exploratory nature of the research inquiry makes a qualitative approach suitable as a means to refine our preliminary research model based on empirical resources (Verschuren & Doorewaard, 2010). We follow the developmental rationale in adopting a mixed-method approach (Venkatesh et al., 2013): findings from the qualitative study will serve as a basis for a quantitative study, in which specified concepts and hypotheses would be tested via experiments.

We will scope our research into the mobility sector due to the sensitive nature of the data in this domain, resulting in a high reluctance to participate in data sharing (e.g. Docherty, Marsden, & Anable, 2018). We will start by conducting a literature review on the core concepts (i.e. B2B data sharing, IOS adoption, digital platforms, and platform control) as well as our research domain (i.e. data marketplaces and MPC). Insights derived from the literature study resulted in an initial research model on how platform control, as realized through MPC, influences firms' intention to share data via data marketplaces. Then, we will conduct a qualitative study in the form of semi-structured interviews with key business actors in the mobility sector. The purposes are twofold: (1) to specify concepts into testable hypotheses and (2) to better understand the causality in the conceptual model. The refined model from the qualitative study will then be tested in the quantitative study via experiments using the mockup of MPC-enabled data marketplaces, which will be conducted via an online crowdsourcing platform. Finally, findings resulted from the quantitative study will then be compared and analyzed with the core concepts of our research as well as insights from the qualitative study. In this way, we can explore explanations on why and how MPC enables platform control, which in turn influences firms'

willingness to share data in data marketplaces. In the end, we will be able to draw conclusions and recommendations from our research.

The mixed-method approach allows us to complement the strength of both qualitative and quantitative research methods (Gable, 1994; Venkatesh et al., 2013). On the one hand, the qualitative meth-od enables us to understand the causality in more detail while maintaining the possibility to discover alternative explanations. On the other hand, the quantitative method allows us to identify the correlation in our findings. In other words, the mixed-method approach will generate a richer understanding of the phenomena under study (Venkatesh et al., 2013).

4 Preliminary Findings

We conducted a workshop with business actors as an exploratory to better understand the barriers and incentives of business-to-business data sharing from the firms' perspective. Understanding barriers and incentives are beneficial to clarify what kind of risks and trust issues that exists, why they affect intention to share data and exploring alternative explanations that are needed to control for in the experiment.

The workshop was conducted in Graz, Austria, in November 2019 as a part of a larger European project. In total, 27 experts and representatives of firms that are interested in the data economy took part in this workshop. Overall, we found barriers that are consistent with our preliminary literature review (see Section 1). Participants were afraid that sharing data with other parties would create knowledge spillovers resulting in competitive disadvantages over rivals. Legal concerns were also dominantly discussed since there is a lack of clarity in terms of process and consequences. Other barriers discussed include the absence of an internal process to support data sharing and the difficulty in quantifying the value of the data.

In terms of incentives for data sharing, participant suggestions are rather straightforward. They demand a clear benefit, either tangible (e.g. money/revenue stream) or intangible (e.g. benchmarking, value-added services). Other participants suggest a clear and established regulation in data sharing as an important incentive

for them. Finally, there is a need for a guarantee and protection of the data to make sure that firms that provide data will maintain their competitive advantage.

5 Expected Contributions

We expect this research to contribute to IS literature, especially on digital platforms and data sharing. Our research will provide a fundamental basis to IS scholars in understanding the "platformization" phenomenon in data sharing. Since data sharing in data marketplaces is substantially different from existing research in the IOS literature, our research will provide a foundation regarding why and how it is different from what we already know about data sharing.

We will also contribute to platform theory by looking into data marketplaces as one specific case study. Even though data marketplaces possess the characteristics of digital platforms, there is hardly any research that uses platform theory as an analytical lens to investigate data marketplaces. Our research will contribute to this gap by attempting to understand how data marketplaces can be viewed as digital platforms and how its governance aspect (i.e. platform control) is essential in driving its adoption.

Concerning adoption studies of digital platforms, this research will attempt to look into end-users' perspectives (e.g. data providers), which is often overlooked in previous research. This research will also become one of the first studies to incorporate platform governance (i.e. platform control) as antecedents of digital platform adoption (i.e. intention to share data in data marketplaces) in a business-to-business setting.

Finally, this research will also provide practical insights into business actors regarding business-to-business data sharing. In particular, providers of data marketplaces may get benefit from this research by considering various strategies in governing data marketplaces to incentivize participation in the platform. They can also consider implementing security technology like MPC to give assurance on data providers so that there is more than enough supply data available to achieve critical mass. Indirectly, this research can also contribute to achieving the vision of the data economy by looking at data marketplaces as one specific case study.

6 Future Development

The next step is to conduct a study on the research domain. The study will provide an overview of data marketplaces in general (e.g., definitions, roles, taxonomy, control mechanisms, challenges, and opportunities) as well as data marketplaces in the mobility industry (e.g., examples, types of data, incentives for data sharing, control mechanisms). Additionally, the study will also provide an overview of MPC (e.g., concepts, comparisons with other cryptographic technique, architecture) and its relation with data marketplaces and control theory (e.g., use case of MPC in data marketplaces, applying control theory to MPC within the context of data marketplaces).

In parallel with the study on the research domain, preparation for the qualitative study will also commence. The preparation for this phase includes the development of interview protocol and identifying potential informants, which will be based on findings of the research domain. Informants will be companies, data marketplaces providers, experts, and consultants in the mobility sector as well as MPC developers/providers. Interviewees will be senior employees with decision making authorities within the organization that has a high-level knowledge of business and technical issues. Interviews will be conducted face-to-face and video calls if necessary. Since this research is part of the larger European project[1], we will interview relevant people from the project as well. We will follow the snowball sampling approach, and we will stop the interviews once there are no new insights or information presented. Interviews will be recorded, and all interviewees will be asked to read the transcript for validation.

[1] Safe-DEED project (https://safe-deed.eu/). There is also a 'sister-project' TRUSTS (https://www.trusts-data.eu/) which is highly relevant with this research.

Acknowledgments

The research in this paper has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 825225.

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MOTOR INSURANCE POLICIES EXPOSURE RISK ASSESMENT

BORIS PERŠAK[1] & DAVORIN KOFJAČ[1]

[1] University of Maribor, Faculty of Organizational Sciences, Kranj, Slovenia, e-mail: boris.persak@student.um.si, davorin.kofjac@um.si

Abstract Expired car insurance policies allow assessment of realized insured risks, while increased number of mature policies fuels actuarial modeling of price basis for the future sustainability of the insurance model. Renewed insurance contracts without changes of conditions and coverage represent approximately the same level of potential risk exposure, while any additional coverage or change of conditions pose imminent higher exposure to realization of covered risks. Such an exposure is even higher when vehicle or person freshly joins the portfolio without known previous policy or moving from another insurance company as the claims and policy history is unknown. With shopping for better price and transitions between insurance companies comes exposure for higher claim numbers due to possible concealment of pre-damaged vehicles. The aim of this research is to show the claim risk exposure difference between in-house renewals of policies and arrivals from outside sources.

Keywords: insurance, policy, risk, exposure, prevention.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.50
ISBN 978-961-286-362-3

1 Introduction

Studies of scientific articles and other publications have shown that many researchers do not have access to live up-to-date data in insurance processes (Pathak et al., 2005), and these data, which, as a rule, exceptionally do not represent the actual complete scope of all data of a particular period, but only a narrow set that was sent to investigators (Zeigler, 2016; Do Vale, 2012) or data from more than a decade ago (Viaene et al., 2005). Collecting, verifying and comparing the data collected is complex (Bawden and Robinson, 2008) and requires a high degree of concentration, while the amount and expanded number of sources of information, which are growing exponentially, contribute to the complexity (Bănărescu, 2015), therefore, information saturation or overload occurs (Klausegger et al., 2007), which has a negative impact on the ability to fulfill work responsibilities.

Considering the fact that automated systems are becoming ever more efficient, especially through the use of artificial intelligence, and are increasingly replacing humans in a variety of tasks (primarily in monotones, where there is a risk of numbness), this makes all the more sense in processes where humans can not develop its capabilities to such an extent that it can effectively process all available data (Karr-Wisniewski and Ying Lu, 2010).

By automatically collecting and formulating information into meaningful business intelligence and delivering it to users in real time when they need it (Khademhosseinieh and Khan, 2009), we enable process owners to make qualitatively and quantitatively sound decisions. Therefore, in order to make effective decisions in business processes, it is necessary to set up optimized data warehouses that enable automated data processing and offer efficient analytical processes, both for actuarial calculations of future exposures and to guide the business process itself throughout the life cycle of the policy.

Insurance is based on probabilistic calculations and large numbers, and actuaries maintain the system sustainability (Tennyson and Salsas-Forn, 2002) by calculating the required inflows, while damage assessors/liquidators optimize outflows. Insurance sellers, risk assessors, and product developers are moving in-between, and other support services, not least insurance investigators, support everyone else. These calculations are based on historical data, or in other words, past results. The

"glass ball" of actuaries depends on whether or not the forecast is correct. That way the insurance company will withstand the pressure of unforeseen large-scale, major or massive claims. There are two actuarial measures that can sufficiently describe the result of an insurer, seller or policy holder to such an extent that it is possible to make an indicative credit rating that guides business decisions and determines the starting points of the products and conditions under which they are offered. These two measures are the claims frequency and loss ratio that can be divided into lower levels, e.g. to the coverage level, person, vehicle, seller, sales channel, or line of business (i.e. Motor, Life, Personal, Property etc.).

Insurance operates according to the principle of burden-sharing among policy holders, but it cannot be avoided by balancing the conditions under which insurance is accessible to all, and in the fairness of distribution it cannot be held that more frequent claimants pay a little more than those who are more caring and probably also less aggressive in claiming benefits (bonuses, discounts, etc.) because of this trait. In order to implement individual treatment of clients, it is necessary to establish an extremely complex analytical structure to spread the burden evenly among insureds and to sustain solvency.

2 Problem definition

There is an operational assumption that policies with no pre-policies or with outer pre-policies have a significantly higher exposure of reported claims compared to the renewal of insurance policies (the insurance company's own pre-policies).

We wanted to check the validity of that assumption and to expose even more operationally credible evidence to eliminate possible bias that could threaten good judgment in insurance processes.

The purpose of this research is to evaluate potential differences in the exposure potential of issued motor policies with respect to the origin of the prior policy (hereinafter referred to as the pre-policy). First, we were interested in an exposure comparison between the group of policies with the company's own pre-policies (renewal of insurance) against the group of all other policies, and against the exposure results of the whole motor portfolio. We extended our analysis to test the exposure differences between the groups of policies with transitions from individual

insurance companies in the local market against the group of renewed policies and against the group of policies with pre-policies of foreign insurers and the group of policies without pre-policies, all of them compared to the exposure results of the whole motor portfolio.

3 Methodology

We set the following starting points for the data range of the observed policies and claims:

- motor insurance policies in the observed insurance company are valid for up to one year,
- we performed an analysis for the policies between January 1st 2013 and December 31st 2018, so all of the observed policies were expired,
- a simple measure of exposure is the number of registered claims compared to the number of issued policies.

First we obtained the data of policies issued after January 1st 2013 that had valid status, then we cleaned the data of all illogicalities and mistakes, and uploaded it into the table of car policies of a dedicated analytical database. We also obtained the data of registered claims after January 1st 2013, cleaned the data of all illogicalities and mistakes, and uploaded them to the claims table of the dedicated analytical database.

To compare the groups of policies according to the origin of the pre-policies, we counted the number of all unique car policies for the observed period of six years between January 1st 2013 and December 31st 2018 with the distribution by years and the number of reported unique claims by these policies. Additional criterion was the source of pre-policies, after which we calculated the exposure for comparison between previously described groups of policies by origin of pre-policies.

The obtained data was processed in Excel with tables and graphical presentations of results by years, which enables comparison between defined groups according to the origin of the pre-policies, the sales channel, or the obligation to inspect and photograph the vehicle.

4 Preliminary results

Exposure indexation was performed for tables and graphs, and the exposure of a group of policies with own pre-policies (policy renewals) was used as the base for calculating the index.

4.1 Test of assumption: exposure comparison of a group of renewed policies (own pre-policies) vs. the group of all other policies vs. the group of all motor policies

Comparison of table data and graphical representations by year according to the origin of the pre-policy confirmed that the group of renewed policies (own pre-policy) had lower exposure compared to the group of all other policies in all years except in 2015 (*Table 1, Figure 1*), in which the renewed policies group had greater exposure. Exposure of group of all other policies has increased significantly over the last three years, with a significant jump in 2017 (*Figure 1*). Comparison of group of renewed policies against whole motor portfolio reveals that the same observation of detected trends from 2015 and 2017 (both in *Figure 1*)is applicable to comparison between renewed policies and all other policies as well.

Table 1: Exposure index distribution of groups of renewed policies vs. all other policies vs. the group of all motor policies

pre-policy source	2013	2014	2015	2016	2017	2018
POLICIES WITH OWN PRE-POLICIES	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
ALL OTHER POLICIES	104,76%	103,92%	95,67%	110,35%	121,28%	107,83%
SUM (ALL)	101,07%	100,88%	99,14%	102,16%	105,29%	101,43%

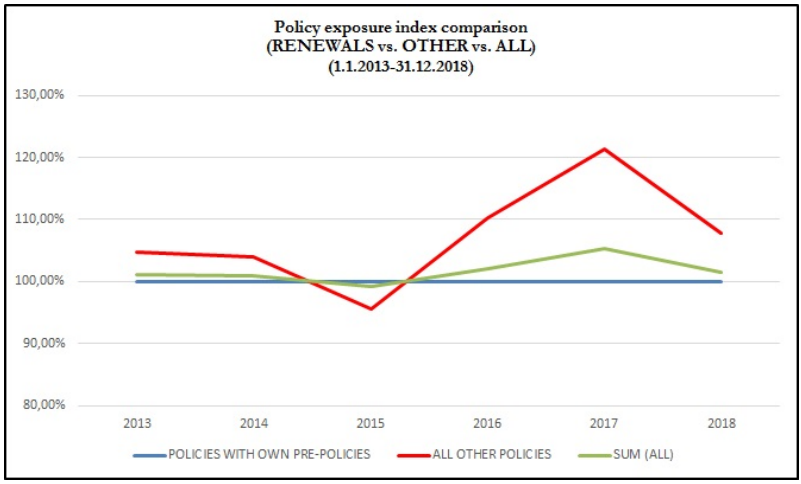

Figure 1: Policy exposure index comparison between the group of renewed policies, the group of all other policies, and the group of all policies of motor portfolio

4.2 Extended test of assumption: exposure comparison of a group of renewed policies vs. the groups of policies with transitions from individual insurers from local market vs. the group of policies with transitions from foreign insurers vs. the group of policies without pre-policies vs. the group of all motor policies

The extended test of an assumption compares exposures between all the groups of policies by sources of pre-policies with results indicating a significantly higher exposure of policies with transitions from other insurers in the local market, with only one local insurer SLO_INS_1 having a negligible decrease in 2015 compared to policy renewals group (*Table 2, Figure 2*), which subsequently increased sharply. The extended test reveals a true picture of the exposure of groups of policies with transitions from other local insurers, with three insurers having significantly higher exposures, while for the most exposed insurer SLO_INS_5 the exposure risk decreased, which can also be attributed to the beginning of the withdrawal from the market (*Figure 2*). The sudden occurrence and the large exposure jump for the insurance company under the code SLO_INS_6 in the last year of the observed period is statistically insignificant, since it represents barely 0.11% of all policies and 0.16% of all claims (*Table 3, Table 4*), which can be attributed to entrance to the local market.

Table 2: Exposure index distribution for all pre-policy sources through observed years

Pre-policy source	2013	2014	2015	2016	2017	2018
NO PRE-POLICY	75,57%	74,11%	69,52%	85,07%	91,87%	79,99%
FOREIGN INS. CO. PRE-POLICIES	136,35%	96,63%	86,74%	66,94%	90,21%	86,99%
OWN PRE-POLICIES	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
SLO_INS_1	113,16%	110,11%	98,35%	102,47%	126,74%	114,12%
SLO_INS_2	108,73%	107,34%	101,94%	121,56%	116,38%	122,89%
SLO_INS_3	131,78%	104,69%	106,87%	134,23%	160,28%	127,06%
SLO_INS_4	115,04%	118,45%	110,83%	123,61%	138,66%	129,23%
SLO_INS_5	164,05%	179,40%	129,45%	179,77%	131,61%	137,18%
SLO_INS_6	0,00%	0,00%	0,00%	0,00%	0,00%	149,16%

Table 3: Distribution of policies by sources of pre-policies

	% of all policies					
Pre-policy source	2013	2014	2015	2016	2017	2018
NO PRE-POLICY	5,24%	5,71%	5,47%	5,88%	6,76%	6,79%
FOREIGN INS. CO. PRE-POLICIES	0,13%	0,14%	0,18%	0,20%	0,27%	0,24%
OWN PRE-POLICIES	77,44%	77,70%	80,01%	79,13%	75,15%	81,74%
SLO_INS_1	3,16%	2,59%	2,56%	2,73%	2,79%	2,03%
SLO_INS_2	6,27%	5,75%	4,85%	4,27%	4,61%	2,96%
SLO_INS_3	0,38%	0,42%	0,33%	0,73%	1,77%	0,92%
SLO_INS_4	7,15%	7,31%	6,39%	6,69%	8,03%	4,87%
SLO_INS_5	0,22%	0,38%	0,21%	0,36%	0,61%	0,34%
SLO_INS_6	0,00%	0,00%	0,00%	0,00%	0,00%	0,11%
SUM (ALL)	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Table 4: Distribution of claims by sources of pre-policies

	% of all claims					
Pre-policy source	2013	2014	2015	2016	2017	2018
NO PRE-POLICY	**3,91%**	4,19%	**3,84%**	4,90%	**5,90%**	5,35%
FOREIGN INS. CO. PRE-POLICIES	**0,18%**	0,14%	**0,16%**	0,13%	**0,24%**	0,20%
OWN PRE-POLICIES	**76,62%**	77,02%	**80,70%**	77,45%	**71,37%**	80,59%
SLO_INS_1	**3,53%**	2,83%	**2,54%**	2,74%	**3,36%**	2,29%
SLO_INS_2	**6,75%**	6,12%	**4,99%**	5,09%	**5,09%**	3,58%
SLO_INS_3	**0,50%**	0,43%	**0,35%**	0,95%	**2,69%**	1,15%
SLO_INS_4	**8,14%**	8,58%	**7,14%**	8,10%	**10,58%**	6,21%
SLO_INS_5	**0,36%**	0,68%	**0,27%**	0,64%	**0,77%**	0,46%
SLO_INS_6	**0,00%**	0,00%	**0,00%**	0,00%	**0,00%**	0,16%
SUM (ALL)	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

The only surprises are the groups of policies without pre-policies and policies with transitions from foreign insurers as their exposure lays moderately to significantly lower in comparison to the exposure of renewed policies.

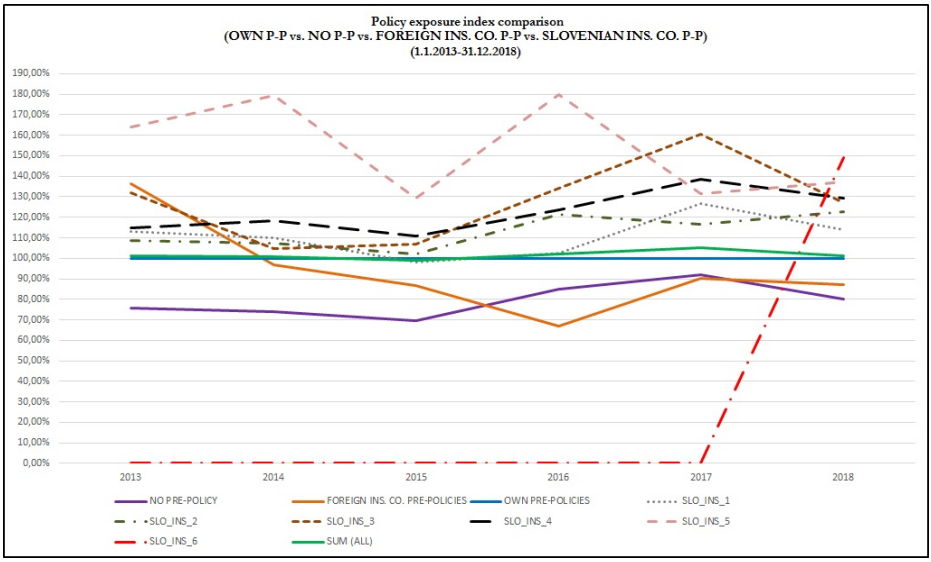

Figure 2: Policy exposure index comparison between the group of renewed policies, the groups of policies with transitions from individual insurers from local market, the group of policies with transitions from foreign insurers, the group of policies without pre-policies, and the group of all policies of motor portfolio

Comparing assumption to the results from both analysis we can conclude that the operational assumption derived from practical experience generally holds true when observing exposure of group of all other policies vs. exposure of group of renewed policies, even more confirmed by comparison of groups of policies with transitions from other insurers in the local market which have from a moderate to a significantly higher exposure ratio compared to renewed policies, while a group of policies with no pre-policies and a group of policies with transition from foreign insurance companies have a moderately to significantly lower exposure ratio compared to renewed policies.

5 Future development and research

The simple measure of exposure is based on historical data and has some useful predictive value for the likelihood of reporting claims for future policies, which can be used for preventive measures such as inspection of vehicles upon admission to insurance. The stated predictive value of exposure has proved to be useful in practice, especially combined with damage history of the vehicle, customer and agent / broker, the age of the vehicle and with presence of the high exposure insurance cover added to the policy as well.

There are more than just the assumption of increased exposure of policies with outer pre-policies vs. renewed policies, especially in the direction of differences between internal and external distribution channels policies exposures, differences between distribution channels without obligation for initial inspection and photographing of insured vehicles vs. the rest of distribution channels where inspections and photographing of the vehicles are mandatory, the issues with age and make of the vehicles, influence of age of insureds on exposure and of course prejudice against many partners or customer groups from specific national backgrounds.

As the present analysis has shown, these assumptions can also be biased, at least to some degree and therefore they need to be addressed and investigated for more accurate and correct handling at all stages of the life cycle of insurance policies.

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DIGITAL TRANSFORMATION IN MARITIME TRANSPORT AND SEAPORTS

MARIJA JOVIĆ[1]

[1] University of Rijeka, Faculty of Maritime Studies, Studentska ulica 2, Rijeka, Croatia, e-mail: jovic@pfri.hr

Abstract The paper presents "PhD by Publication" steps, including the topic of digital transformation in maritime transport and seaports. Author plans to follow a "PhD by Publication" guidelines, in which the doctoral thesis is composed of published scientific papers during the PhD study. Author considers two approaches: including published papers and publishing new papers. Author is currently working on the paper "Digital transformation in maritime transport sector", which will include drivers, success factors and barriers for digital transformation in maritime transport sector. It is a base for future research: case study with semi-structured interview.

Keywords: PhD by publication, digital transformation, maritime transport sector, seaports, doctoral consortium.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.51
ISBN 978-961-286-362-3

1 Introduction

Transport has always had an impact on economic growth, and ecological and social development (Jović, Kavran, Aksentijević, & Tijan, 2019). On the other hand, transport is one of the main causes of environmental pollution (Dimić, Pamučar, Ljubojević, & Dorović, 2016), (Tijan, Jović, & Karanikić, 2019).

Not all industries are equally developed and the maritime transport sector is among the slowest sectors regarding the digital transformation (World Maritime News, 2018). Only a small number of industry players in the maritime sector consider that digitalization has already changed their business significantly, whereas companies in high-tech and in public transport have already seen greater changes from the pressure of digitalization (Hamburgisches WeltWirtschafts & Institut, 2018).

Despite numerous advantages, enterprises are still facing the challenges of digital transformation in almost all industries, including seaports which are part of the maritime transport sector. Seaport is a nodal point between land and sea, or a modal interface between shipping or sea transportation system on the one side, and the land transport network on the other side (UNCTAD secretariat, 2004).

Author aims to identify (through comprehensive literature review) drivers of digital transformation, as well as success factors and barriers of digital transformation. Author plans to take advantages of the "PhD by Publication model, which is still very rare in Croatia. In this model, the doctoral thesis is composed of published scientific papers written as part of the research at the PhD study, published after the enrollment into the PhD program. These scientific papers are supplemented by a common introduction and joint conclusion (Faculty of Economics Rijeka, 2019).

Author is currently working on the paper which will be submitted to a top journal (Q1 journal indexed in the Web of Science database, following the "PhD by Publication" rules which are further explained in the Methodology section).

2 Problem definition

The research problems stem from the lack of awareness of how digital trends affect business development, lack of managers and employees' involvement or desire to change current practices, insufficient budgets for digital initiatives, etc. in maritime transport sector. Furthermore, maritime transport is moving towards digitalization at different speeds in the different domains (Sanchez-Gonzalez, Díaz-Gutiérrez, Leo, & Núñez-Rivas, 2019).

3 Methodology

According to the "PhD by Publication" guidelines, the doctoral thesis is composed of scientific papers written as part of the research at the PhD study, published after the enrollment into the PhD program. These scientific papers are supplemented by a common introduction and joint conclusion (Faculty of Economics Rijeka, 2019).

Each article can serve to qualify only one doctoral candidate, unless a special explanation is provided. The doctoral candidate needs to be a lead (first) author in at least three of the articles. The collected works need to present a new scholarly contribution relative to the individual articles.

Scientific papers must be published in journals with an impact factor according to the Journal Citation Report (JCR) in the year of publication. At least two papers must be published in journals with an impact factor higher than the median of the respective category and of these two papers at least one must be published in the first quartile (Q1) journal of the respective category.

The author will consider two approaches: including published papers through keywords and publishing new papers.

3.1 Including published papers

In order to prove a connection between papers, author must highlight the keywords as shown in the Table 1.

Table 1: Author's published papers

Author's published papers	Key words
An Overview of Security Challenges of Seaport IoT Systems (Jović, Tijan, Aksentijević, & Čišić, 2019)	Internet of Things, Seaports, Security systems
The Transition of Croatian Seaports into Smart Ports (Jović, Kavran, Aksentijević, & Tijan, 2019)	Smart ports, Smart technologies, Interconnected platforms, Croatian seaports
The role of Electronic Transportation Management Systems in Seaport Digitalization (Jović, Tijan, Aksentijević, & Sotošek, 2019)	Electronic Transportation Management Systems, Seaports, Digitalization, Business Processes
Economic and ecological aspects of electronic Transportation Management Systems in seaports (Tijan, Jović, & Karanikić, 2019)	Electronic Transportation Management Systems, Seaports, Economic aspects, Ecological aspects
Digital Transformation of Croatian Seaports (Consortium) (Marija Jović, 2019)	Digital transformation, Transportation companies, Maritime transportation, Seaports, Shipping companies
The Single Window concept in international trade, transport and seaports (Tijan, Jović, Jardas, & Gulić, 2019)	Electronic data exchange, Standardization, International trade, Transport, Seaports, Single Window
Maritime National Single Window — A Prerequisite for Sustainable Seaport Business (Q2) (Tijan,	Maritime national single window, Seaport business, Sustainability

Agatić, Jović, & Aksentijević, 2019)	
A review of blockchain technology implementation in shipping industry (Jović, Filipović, Tijan, & Jardas, 2019)	Blockchain technology, Shipping industry, Seaports
Big Data Management in Maritime Transport (Marx, Gebhard, Jović, & Tijan, 2019)	Big Data Management, Big Data Analysis, Maritime Transport, Shipping Safety, Energy Efficiency
SWOT analysis of selected digital technologies in transport economics (unpublished)	Digital technologies, Digital innovations, SWOT analysis, Transport economics
Optimization of cargo container loading on railway wagons (unpublished)	Railway, Wagons, Cargo, Intermodal, Liberalization

Source: author

In order to find the connection between the published papers, author has focused on the research keywords and has highlighted similar or identical keywords.

Currently, author considers including three published papers: *The Transition of Croatian Seaports into Smart Ports*, *An Overview of Security Challenges of Seaport IoT Systems* and *Maritime National Single Window — A Prerequisite for Sustainable Seaport Business* (belongs to a second quartile journal – Sustainability, published by MDPI). Along with that, author is working (in collaboration) on the paper regarding digital transformation (author plans to submit the paper to a first quartile journal) which will include drivers, success factors and barriers for digital transformation in maritime transport. At last, in the same paper, authors will analyze current initiatives and technologies and their role in successful digital transformation of maritime transport (Internet of Things, Blockchain, Big Data etc.). Furthermore, several examples in maritime transport sector will be demonstrated (port of Rotterdam, port of Koper, Maersk, CMA CGM, etc.), proving throughout the work that for successful digital transformation, it is not enough to focus only on technologies, but also on other identified factors, e.g. actively shaping future strategies, partner and employee engagement etc.). The aforementioned published papers are suitable for the "PhD by Publication" model as they include an analysis of smart technologies

(from the perspective of less developed seaports – Croatia could serve as an example, and from the security perspective). Furthermore, *Maritime National Single Window — A Prerequisite for Sustainable Seaport Business* is a paper which researches the cases of MNSW (another widespread technology) implementation, both successful and less successful.

3.2 Publishing new papers

Currently, author researches the drivers, success factors and barriers of digital transformation in maritime transport. While analyzing the published sources, author has realized that the literature review alone is not sufficient for the final research model. In this respect, author is going to publish a case study with a semi-structured interview. Semi-structured interview may be defined as "a list of themes and possibly some key questions to be covered [by the researcher], although their use may vary from interview to interview". The goal is to enable the interviewees "to discuss topics they deemed relevant, to post follow-up questions and to generate new and additional insights." (Arpe, 2019).

4 Preliminary/Expected results

The drivers, success factors and barriers will be identified and possible positive impacts of digital transformation (if all success factors are considered) will be analysed, stemming from the lack of awareness among stakeholders of how digital trends affects business development, lack of managers and employees' involvement or desire to change current practices, insufficient budgets for digital initiatives, etc. in maritime transport sector (Ultimate Software, n.d.). Figure 1 shows the research steps and expected outcomes.

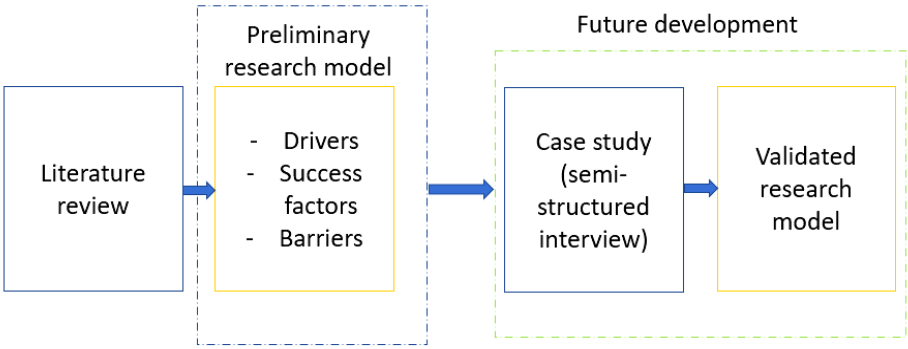

Figure 1: Research steps and outcomes
Source: Author

A case study will provide a deeper insight of digital transformation in maritime transport. Case study will be further elaborated in the chapter "Future development".

Furthermore, other published papers provides a deeper understanding of how certain technologies (Internet of Things, Maritime National Single Window) may affect a successful implementation if other successful factors are (not) considered. For example, one of the barriers for digital transformation is "decreased security of digital operations". A published paper "An Overview of Security Challenges of Seaport IoT Systems" includes identified threats, measures for prevention of the IOT security threats, consequences of connecting the devices (IOT) at the seaports with emphasis on the security (providing cases such as Port of Rotterdam, Port of San Diego, Port of Antwerp etc.).

5 Future development

The comprehensive literature review is a basis for a future research (case study) regarding digital transformation in maritime transport sector. The goal of the further research is to gain a deeper understanding of how stakeholders cope with the market changes (changes in competitive landscape, costumer expectations etc.). Eventually, author will focus on the steps which companies in maritime transport sector should take, considering their current development, available resources, cultural readiness for changes etc. Author plans to partially follow up on the research results of two

papers "Digital transformation strategy making in pre-digital organizations: case of a financial services provider" (Chanias, Myers, & Hess, 2019) and "Patterns of Digitization, A Practical Guide to Digital Transformation" (Mugge, Abbu, Michaelis, Kwiatkowski, & Gudergan, 2020).

This paper could serve as an example to other PhD students in understanding the steps for "PhD by Publication". Based on this work, other researchers will be able to upgrade the methodology, encouraging other students to embrace the "PhD by Publication" model.

Acknowledgements

This work was supported by University of Rijeka under the Faculty of Maritime Studies projects.

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AUTOMATIC GENERATION OF TEST CASES FROM USE-CASE SPECIFICATION USING NATURAL LANGUAGE PROCESSING

MARKO PRIBISALIĆ[1]

[1] University of Rijeka, Department of Informatics, Rijeka, Croatia, e-mail: marko.pribisalic@gmail.com

Abstract Software testing often targets natural language specification documents. The initial assumption is that automation of creating test cases from natural language specification is of benefit to speed up testing enabling a better coverage of all possible test scenarios. The proposed enabling principle for automatic generation of test cases is automatic retrieval of logic for the interaction with an application. After retrieving, interaction logics is transformed into decision tables. Next, from decision tables it is possible to automatically generate test cases. Because in our research we target Croatian natural language, the assumption is that is it necessary to create a new approach to achieve the set goal. The main research questions posed in this paper are: "Is it possible to automatically generate test cases from use-case specifications written in the Croatian language?"; "Natural language processing tools for automatic test-generation save the tester's time and effort while improving the quality and coverage of the test cases?". The expected results are to defining the method that using test-case generation tools reduce the time and effort for software testers and improve the test coverage of requirements.

Keywords: test case, semantic analysis, logical specification, natural language processing, croatian language.

University of Maribor Press

DOI https://doi.org/10.18690/978-961-286-362-3.52
ISBN 978-961-286-362-3

1 Introduction

Software testing is a fundamental activity to ensure the quality of software systems. Test engineers conduct most (if not all) phases of software testing manually. One of those phases is test-case design in which the human tester uses written (formal) requirements (use-case specification), written often in natural language (NL), to derive a set of test cases (Garousi et.al, 2015). IEEE (1998) recommends the standard for software requirements specifications in praxis. The standard describes consideration for producing a good software requirements specification, parts of them and provide templates. Recommendations and standards intended to help: software users (customers) to accurately describe what they wish to obtain; software suppliers to understand exactly what the customer wants; individuals to develop and define the format and content of software requirements specification (SRS) outline for their organizations. Usually, test cases are created manually, so test case coverage depends upon each individual tester's skill, preferences and knowledge. Under these circumstances, it is difficult to create high coverage test cases. High coverage test cases systematically consider all functionalities described in corresponding specifications. The second characteristic stemming from leaning exclusively on tester's skills and experience is a demand to translate business rules specified in the free form of natural language info formal use-case tests. In order to cover all functionalities described in use-case specifications, it is important to find the correct technique to retrieve software logics needed to test all possible interactions between users and software. Semantic analysis technique facilitates the retrieval of interaction logics enabling automatic creating of test cases. Once the interaction logics are retrieved, they can be represented in the form of a decision table which subsequently enables the creation of the test cases (Masuda et.al, 2013). Previous research studies (Saeki (1989), Sneed (2007), Kim (2008), Uetsuki (2013)) consider software specifications written in the English language. Engaging languages other than English requires substantial adjustment of proposed techniques. For instance, if specifications are in the Croatian language, for automatic generation of test-case scenarios it is a prerequisite to include NLP techniques for the Croatian language. Finally, by including adequate semantic analysis technique and tools for automated test case generation, we believe that we will get a successful model for automated test case generation from specifications written in Croatian. Specifically, we aim of combining semantic analysis technique and tools for automated test case generation

to create a model for automated test case generation from specifications written in Croatian.

2 Problem definition

Creating test cases is a challenging and time-consuming endeavour in the process of software testing which consists of test case generation, test execution, and test evaluation. In the software test life cycle, test case generation takes 40-70% of that process (Kulkarni & Joglekar, 2014). In the testing process, the practice is to manually write the test cases based on the provided functional requirements of the software. Under these circumstances, it is challenging to create high coverage test cases, while testing requires covering and testing all functionalities in software as described in use-case specifications. It is not uncommon that testers created test cases that do not match which the product owner's needs because not all the testers have prior knowledge of how the system is working (Broek et.al, 2014). Auto generation of test cases can contribute to saving money and time, improving the quality of testing and ensuring better test coverage. Automatically generated test case preferably ensure easier maintenance and reuse of test cases if deemed necessary.

These difficulties have led to the incorporation of different sub-fields/disciplines of NLP to be ported and tested for automatic generation of test cases form specifications written in natural language. Though natural language processing tasks are closely intertwined, they are frequently subdivided into sub-fields/categories for convenience. In this study, we are mainly tasked with information extraction (IE). Information extraction (IE) is the task of automatically extracting structured information from unstructured and/or semi-structured machine-readable documents and other electronically represented sources. (Berti-Equille & Borge-Holthoefer, 2015). In planned work focus will be on automatic test-case generation from use-case specifications written in the Croatian language. The reason stems from the present situation in Croatian IT companies that are focused on the Croatian market, hence services, software and specifications as well are written in Croatian. Croatian is different from the English language, so it is worth noticing some major differences. "Croatian is a highly flective Slavic language and words can have seven different cases for singular and seven for plural, genders and numbers. The Croatian word order is mostly free, especially in non-formal writing. These features place Croatian among morphologically rich and mostly free word-order languages. English

grammar has minimal inflection compared with most other Indo-European languages, therefore it is considered to be analytic. English word order is almost exclusively subject-verb-object. Both languages are characterized by an accentuation system developed on syllables" (Martinčić-Ipšić et.al, 2016).

The research questions we put forth are:

RQ 1 - Is it possible to automatically generate test cases from use-case specifications written in the Croatian language?

Sneed (2007) presented the automated testing of software against natural language requirements. The approach was to analyze requirements and automatically extract test cases. The tool is the text analyzer developed by the author. The text analyzer scans through the requirements text to pick out potential test cases based on keywords and sentence structure. The Sneed (2007) approach has an error discovery rate of 89%. It is a much cheaper and more efficient way of exposing errors than a pure manual test case selection process. In this case, over 95% of the potential functions were covered, which means that the approach achieved higher functional test coverage. Saeki et.al (1989) presented a software development process from natural language specification. That was an approach to solve problems about natural language specification by the process, which was defined as "design" and "elaborate". The approach was not applied for automatic derivation of test cases from specifications in natural language processing. Kim et.al (2008) presented a measurement of the level of quality control activities in software development. Overall quality control score can be calculated by evaluation each of fourteen quality metrics which are adopted as a key performance index constituting of quality control level. As quality metrics are suggested the measurements of specification documents, for examples, document defect density, document reusability and so on. Natural languages are inherently ambiguous which makes the requirements documented in use-case specification document unclear. This unclear requirement causes that developers develop software which is different from the specification and discrepant with customer needs (Sabriye & Zainon, 2017). Uetsuki et.al (2013) presented an efficient software testing method by decision table verification. They propose a knowledge creation method of software logic extracted automatically from the programme source code. All possible programme paths are extracted from source code, then converted into a decision table. The logic verification can be performed

in a short time by comparing the decision table with a specification of software. Matsuodani (2012) showed that retrieving logics from specification documents into decision tables is beneficial and suggested the opportunities for future use of decision table. The semantic analysis technique can detect ambiguity in the logic of specification documents and feedback measurements for document quality. The semantic analysis technique can feedback the analyst to write manually specification documents more precise. The more exact we can describe logic in the specification documents in advance, the less workload to fix of incorrect logic will be needed. When experts did not understand the logic of the sentences, it must be something incorrect in the sentences, it is called incorrect logic (Masuda et.al, 2015).

Our focus will be on applying the results of Croatian natural language processing into software testing. We plan to propose a semantic analysis for testing logics retrieval from Croatian use-case specifications. Garousi et.al (2018) points out that many authors in previous research as dominant language use English for requirements specification. Yet several research studies have been reported for other languages. Masuda et al. in (Masuda et.al, 2013; Masuda et.al, 2015) have focused on automatic test-case generation in Japanese (Masuda et.al, 2013; Masuda et.al, 2015) while Yang et al. in (Yang et.al, 2017) develop testing from Chinese specification documents. It is worth noticing that each natural language has specifics requiring adjusted of semantic analysis techniques for logics retrieval. The semantic analysis technique, besides facilitating automatic testing procedures can provide feedback on improvement of the manually written specification. The more exact we can express software logic in specification documents, the less workload will be in testing and subsequently fixing of incorrect logic. To prove that the semantic technique works properly, we plan to do a comparative analysis, which will be focused on automatic test-case generation from English and Croatian use-case specifications.

RQ 2 - NLP tools for automatic test-generation save the tester's time and effort while improving the quality and coverage of the test cases?

Ther are several possibilities for evaluation of the quality of the test cases generated from natural language. The first is based on an activity diagram and activity graph. Activity diagrams, also known as control flow and object flow diagrams, are one of the UML (unified modelling language) behavioural diagrams. These diagrams are suitable for business process modelling and can easily be used to capture the logic

of a single use case, the usage of a scenario, or the detailed logic of a business rule (OMG, 2020). Activity graph is a graphical method for showing dependencies between tasks (activities) in a project (Oxford, 2016).

The parameters to assess the quality of the test cases generated from natural language or activity diagram are the number of test cases created and the effort required to create the test cases. Activity Diagrams are converted into activity graphs for the purpose of visualization and to implement the algorithms. Since the test cases are generated from the activity graph, the following criteria determine where the testing process terminates and how good a test coverage does the generated activity graph provide (Mingsong, 2006):

- **Activity Coverage** - The generated test cases must ensure that all the activity states in the diagram are covered sequentially, from the initial node to the final node, at least once;
- **Path Coverage** - The generated test cases must ensure that all possible paths from the initial node to the final node are covered at least once in the activity graph.
- **Transition Coverage** - The generated test cases must ensure that all possible transitions/edges from the initial node to the final node are covered at least once in the activity graph.
- **Predicate Coverage or Branch Coverage -** In the case of a decision node, the generated test cases must cover the true and false logic paths of the condition.

If the generated test cases are executed and linked to defects in the software workflow, parameters such as rework ratio, defect detection percentage, and test execution rates can be used to verify the quality of the test cases.

The **effort required** to generate the test cases is the average time taken to generate the test cases (Elghondakly et.al, 2015).

Test Case Productivity (TCP) is defined as the ratio of the number of test steps/test case generated to the effort (in hours) taken to generate these test steps (Gulechha, 2009).

3 Importance of research (why it is worthy of doctoral research)

The focus of our research is the automatic generation of test cases from use-case specifications using natural language processing to Croatian documents. Software testing according to natural language specification documents is the standard approach for system and acceptance testing (Sneed, 2007). Since we are targeting the Croatian natural language, this is currently an unexplored problem. In this stage of the research, we are aiming to find the right methodology, methods and techniques. At this point, it is not clear to conclude with certainty whether the studied problem will require a creation of a novel technique or will be possible to adapt the existing technique. From previous research dealing with other languages, eg Japanese (Masuda et.al, 2013), we see that this technique needs to include the testing logics retrieval from harmonization between natural language processing techniques and software testing. So our first step will include the study of portability of existing technique to new software testing domain and in Croatian natural language, preferably followed by the development of new technique. Harmonization between natural language processing techniques and software testing is crucial to ensure success to develop test cases.

4 Methodology

In the first phase, we plan to conduct a survey in the form of a systematic literature mapping (classification) and systematic literature review. Objectives are to summarize the state-of-the-art in NLP-assisted software testing. It could open potential directions in utilizing NLP-based techniques for Croatian language and providing an overview of the research areas. For data analysis, we plan to use the automated content analysis approach, which is based on algorithms that use probabilistic topic models (Blei, 2012). Additionally, for the literature review we plan to use a text analytics tool, which automatically analyses text documents to identify high-level concepts and provide key ideas and insights from the text, eg "Leximancer" (Leximancer, 2020). We believe that the literature review will help us to find methods to achieve the previously defined aims.

Based on relevant papers, we plan to propose a semantic analysis technique of logics retrieval for Croatian use-case specifications. The analysis technique can feedback on how we write manually specification documents precisely. The more correct we can describe the logic on specification documents in advance, the less workload to fix incorrect logic.

After the definition of the analysis technique, we plan to verify their relevance by using NLP tools. The success of generating test cases from requirements strongly depends on the right selection and usage of an appropriate NLP method. Initially, we plan to use the Stanford Parser, which offers a broad variety of NLP-related functionalities (Manning et.al, 2014). Stanford Parser supports Croatian (human) languages and it is a frequently used parsing tool. Afterwards, there is a possibility of adding another NLP tools like "NLTK" (NLTK, 2020)).

Ultimately, we plan to carry out the experiment in the Croatian Financial Agency FINA - Informatics Sector / IT Service Development Department / Department of verification solutions who is in charge of public service testing on a daily basis. Software requirements which testers using in everyday work are defined in use-case specifications written on Croatian natural language. We plan to verify that the defined model provides answers to our research questions, and what are the specific benefits of our approach.

5 Preliminary/Expected results

The expected results of using test-case generation tools are: (1) reducing the time and effort for testers and (2) improving the test coverage of requirements. We plan to conduct the testing experiment in two groups of testers. The first group of 2 testers will be given 10 use-case specification for manual test case generation, and the same use-case specification will be given to the other set of 2 testers for automatic test generation, such as proposed in the doctoral dissertation. The results obtained from both groups of testers will be compared with ground truth which will be prepared in advance. Expected results are that the automatic method takes less time as compared to the manual method (quantified by the number of test cases and test steps). We opt to ensure that the increased number of test cases, test steps, and Test Case Productivity generated using the automatic method provide more coverage of the functionality than the manual method. We will evaluate the coverage

of each of the test cases written by the user manually and generated by the user automatically. Also, we expect that we will show that the semantic analysis technique could retrieve testing logics from Croatian natural language specification documents. Finally, by using the correct semantic analysis technique and NLP tools for automated test case generation, we believe that we will develop a successful model for automated test case generation from a use-case specification written in Croatian.

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University of Maribor

Faculty of Organizational Sciences