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Effective implementation of Industry 4.0 technologies in the retail sector through the example of service robots

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Table of contents

List of Figures

List of tables

1. Introduction

The Fourth Industrial Revolution is having an increasingly significant influence across several industries, sometimes referred to as Industry 4.0 or Services 4.0. One of the key factors contributing to this phenomenon is the widespread adoption of digitalization and the rapid proliferation of technological advancements.

I have been interested in digitalization solutions since my undergraduate days. My thesis at the time was on cloud-based systems, and later, as a Master's student, I looked at the impact of certain digitalization solutions in the mobile services industry. This made it quite clear that I would like to work on a similar topic in the future, and I have been interested in different technological solutions since I was a child.

Over the years, I have intentionally developed my dissertation as an article-based one. Utilizing this approach has enabled me to consistently publish my research findings in respected academic journals. This has afforded me the opportunity to receive significant suggestions and guidance on my study, ultimately influencing the course of my final dissertation. Furthermore, it has facilitated my ability to effectively monitor global developments and seamlessly integrate them into my final report via my articles.

Throughout my research, minor and major environmental changes have influenced the final form and direction of the dissertation and the outcome of this research. The raging COVID-19 pandemic in our world has put my original research in a different light. Initially, my research was intended to primarily examine the widespread adoption of industrial robots within the context of Industry 4.0 and their significance in the world of business. Accordingly, at the beginning of my research, together with my supervisor, Erzsébet Czakó, I participated in the "5th AIB-CEE Chapter Annual Conference on International Entrepreneurship as the Bridge between International Economics and International Business" in 2018 with a paper analyzing the readiness of the Visegrad Four countries for Industry 4.0. The aforementioned work has significantly influenced my perspective, leading to my maintaining Industry 4.0 as an essential concept. Moreover, it has served as a catalyst for technological advancements, enabling the widespread integration of robots in many global industries. In the same year, I joined a research group on the impact of Industry 4.0 on industry and continued my research with a focus on retail. Thanks to this research and the unfortunate pandemic, my initial ideas were shaped and changed. Due to COVID-19, the retail industry, among others, has undergone significant changes and has been forced to invest significant resources in digitalization. In recent years, there has been a notable trend toward the adoption of robots. The ongoing COVID-19 pandemic has further emphasized this shift, as there is now a greater focus on maintaining distance between humans. Additionally, the emergence of various digital platforms, such as Foodpanda and Walmart's GoLocal service, has facilitated the connection between smaller retail establishments and large multinational retailers. As a result of these external factors, my research has shifted from a general global quantitative focus to an industry-specific qualitative research direction.

In the context of my doctoral thesis, I aim to address the following research question: What is the influence of digitalization, specifically in relation to service robots, on the worldwide value chain of retail companies? In order to achieve this goal, an analysis will be conducted on the

effects exerted on the front-end and back-end operations of retail establishments, as well as the necessity for the presence of strategic support functions to facilitate these operations. In order to carry out this research in sufficient detail, I will first introduce and define service robots and examine the framework and the way in which digitalization is taking place in retailing, based on the Porter value chain model.

In the beginning of the second chapter of my thesis, I will explain the theoretical background to this topic. I will define Industry 4.0 and its technologies, showing how today's robots differ from those of the previous industrial revolution and how they have spread beyond industrial use to services. I'll explain what digitalization is, how it is spreading, and how Industry 4.0 has benefited from it recently. I'll also discuss the connection between digitalization and dynamic capabilities and its relevance to retail.

From chapter 2.2 till the end of 2.5, I will describe my overarching question in details with defining sub-questions. After this I introduce the purpose of my research and its relevance for the different actors. I will examine the factors that facilitated and justified my choice of topic. I will then describe and justify my chosen methodologies: systematic literature review, document analysis, and interviews with companies and experts.

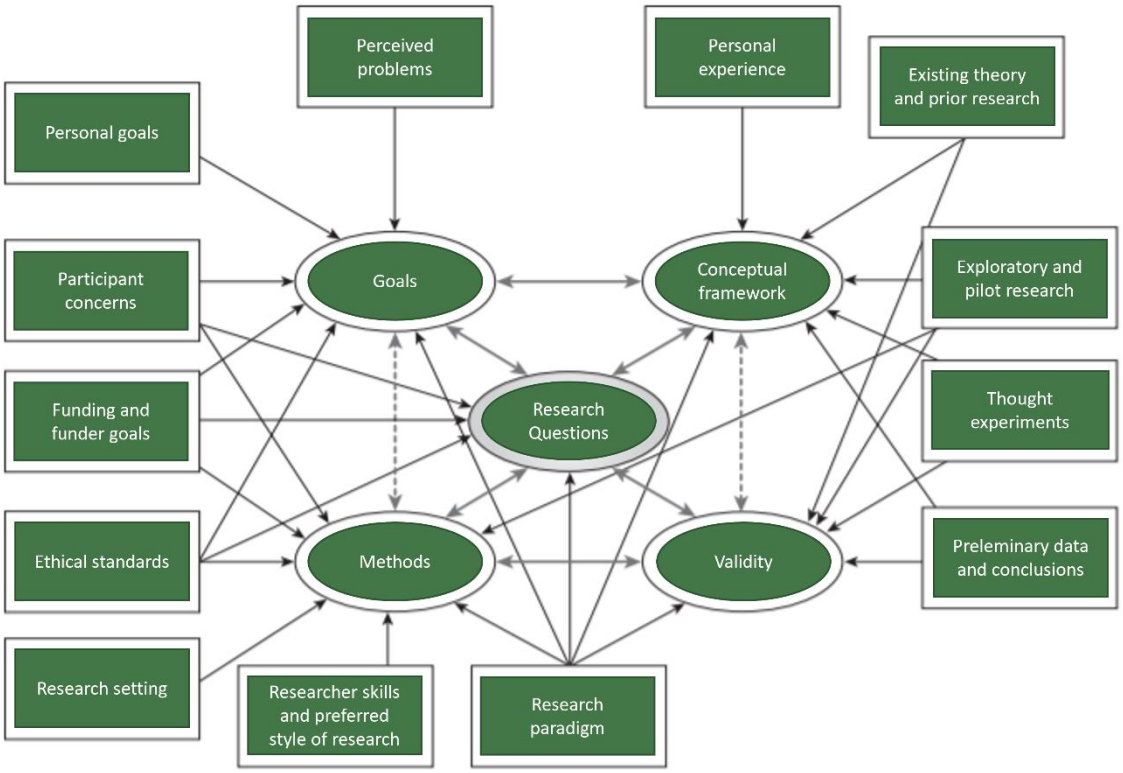
In Chapter 3, I will present my papers and provide an overview of them considering my dissertation research, positioning them within my research framework. I will summarize my writings and discuss how they contribute to addressing my research question. The objective of my research is to establish a connection between the definition of robots and the representation of retail digitalization using value chain theory. This connection is crucial in addressing my main research question and establishing an interpretative and analytical framework for a more comprehensive research of the topic of robots in retail.

In conclusion, I will address my research questions and sub-topics and suggest possible directions for future research.

2. The research design

My research is essentially based on qualitative research methodology. Demonstrating the impact of Industry 4.0 and digitalization on retail through the use of service robots is a topic that is currently difficult to measure quantitatively. The reason for this is the low level of uptake of digitalization and, in particular of the use of service robots. My research design is based on Maxwell 2012 (Figure 1). The second chapter of my dissertation is focused to clarifying my research design. Initially, I will identify the current gaps in research by assessing the theoretical summary. Afterwards, I will define my research question and sub-questions based on this analysis. I will also specify the goals I aim to achieve in doing so. The methodology I have selected to examine these will be given based on the method in which I connect them in the articles. Ultimately, I will outline the steps involved in validating the accuracy and reliability of my dissertation.

Figure 1: Model of the Research Design

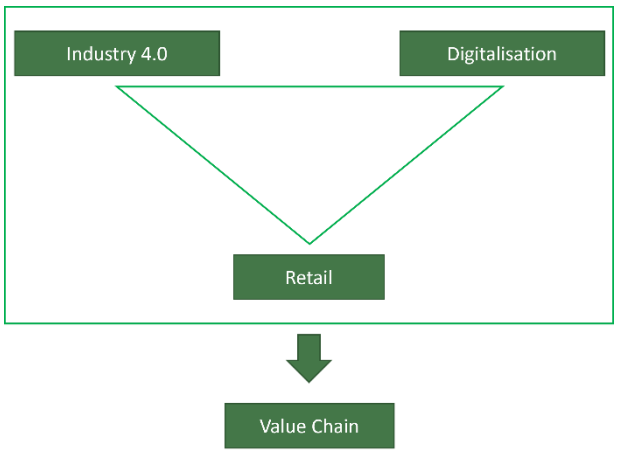


Source: Maxwell (2012, p. 218)

2.1 Theoretical and conceptual background

My dissertation's theoretical foundation is built around Industry 4.0, digitalization, supply chain and value chain models, and dynamic capabilities. This serves as the foundation for the application of integrated technologies and the digitization of the retail industry. (Figure 2).

Figure 2: Conceptual framework of my dissertation



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2.1.1 Industry4.0

The first industrial revolution is thought to have begun with the construction of the first fully functional factories equipped with steam and water-powered machinery. The assembly line and the use of electricity in mass production followed 100 years later. In the 1970s, the development of information technology enabled the spread of electronics, which enabled further automation. The fourth industrial revolution is based on the emergence and spread of CPS (Cyber-Physical System).

The main difference between cyber-physical systems and a simple computer is that they can communicate not only with other software but also with real, physical devices (e.g., sensors).

Numerous works of literature apply various interpretations of the phrase "Industry 4.0" and its meaning. Ślusarczyk's 2018 research examined how these often synonymous terms related to Industry 4.0 appeared in Web of Science, Scopus, and Google Scholar databases. In total, he examined the occurrence of five terms: Industry 4.0, Industry of the Future, Fourth Industrial Revolution, Production of the Future, and Intelligent Manufacturing. His findings indicated that the most commonly appearing word was "industry 4.0," followed by "intelligent manufacturing" in second place. However, researchers disagree on the synonymity of these concepts and treat them separately.

It is difficult to find a generally accepted definition of Industry 4.0. This problem was identified by Culot et al. (2020), who analyzed definitions related to Industry 4.0 in academic and non-academic sources based on six criteria.

1. Title: Industry 4.0 or something else
2. Scope: manufacturing, other sectors, consumer/societal dimension
3. Key enabling technologies: physical/digital interface technology, network technology, data processing technology, digital/physical process technology
4. Other enablers: new business models, enterprise solutions
5. Distinguishing features, e.g., real-time, autonomy

6. Expected outcome: at the firm level, for example, flexibility and productivity; and at the macro level, for example, economic growth.

In my dissertation, I consider Industry 4.0 to be part of the Fourth Industrial Revolution (Demeter & Losonci, 2020), but by no means synonymous with it. Although Industry 4.0 itself has implications for several sectors, not just manufacturing, the term is still mostly used in the context of manufacturing. On the technological side, developments and innovations in manufacturing have an impact and can be used in other industries, including service industries. During the literature review of my research, I had to pay particular attention to which researcher uses which term and by which definition, as one distinguishes between the terminologies while others treat them as synonyms. Consequently, in order to prevent potentially important literature from being removed from the research's emphasis, it is imperative to define Industry 4.0 and stick to it rather than just using the terminology.

Table 1 summarizes the various definitions of Industry 4.0 based on Ślusarczyk's (2018) collection, and I would add definitions from additional researchers.

Table 1: Defining Industry 4.0

Name	Definition
Lasi et al. (2014) in Ślusarczyk 2018, p.234	„Industry4.0 describes the increasing digitization and automation of the manufacturing environment, as well as the creation of digital value chains to enable communication between products, their environment and business partners”
Hermann et al. (2016) in Ślusarczyk 2018, p.234	“Industry4.0 a collective term for technologies and concepts of value chain organization”
Oesterreich & Teuteberg (2016) in Ślusarczyk 2018, p.234	From a technical point of view, this new industrial paradigm can be described as the increased digitalisation and automation of the manufacturing environment and the digital value chain.
Lu (2017) in Ślusarczyk 2018, p.234	“Industry 4.0 can be summarized as an integrated, adapted, optimized, service-oriented, and interoperable manufacturing process which is correlate with algorithms, big data, and high technologies”
Losonci, Takács & Demeter (2019, p.190)	"Industry 4.0 builds on technological opportunities to offer a unique product with enhanced digital service content, organising a new value chain"
Nagy (2019, p.15)	"Industry 4.0 is a phenomenon that builds on technological tools, integrates the business value chain and supply network through a set of activities, exploiting the opportunities of digitalisation to bring a high level of process transparency, and takes customer value creation to a new level by making customised and smart products available."

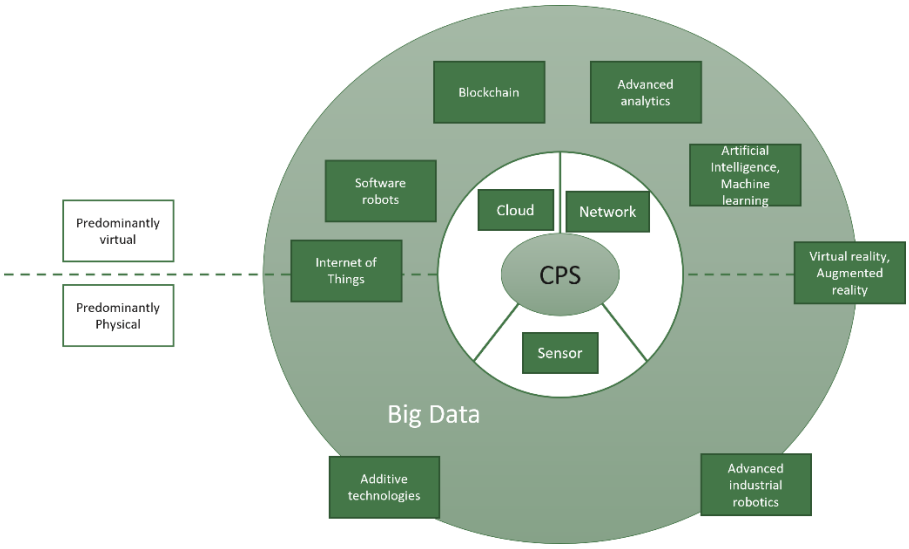
Source: Ślusarczyk 2018, p.234 and own collection

Just as Culot et al. (2020) do not finalize a definition of this phenomenon, it is unlikely to become a generally accepted concept for many years, as it is still ongoing and is constantly changing current organizational operations and reshaping industries. Based on these considerations, in my dissertation, I take as a starting point the role of Industry 4.0 in the diffusion and evolution of technologies and the integration of the enterprise value chain and supply chain, as well as the role of consumer value creation, both in products and services, going beyond a manufacturing-centric approach. Among the above definitions, I follow Nagy's (2019) definition and examine the issues in relation to it. Because of its involvement in supply chains, a lot more data is now accessible than ever before in its downstream stages, like sales. This information can affect, for example, production scheduling and logistics processes, so its integration throughout the supply chain is essential. In this way, the impact of Industry 4.0 can be seen beyond manufacturing and will contribute to the intensification of digitalization or even digital transformation, and, through the continuous evolution of technologies, its impact will be growing and may lead to whole business model changes that may affect the entire supply chain. In their 2018 research, Bertola & Teunissen build on the argument that we should look at combinations of smart manufacturing (including prototyping, final product manufacturing, logistics), smart networks (including communications, supply chain management, and retail), and smart products (e.g., packaging, products, inventories) rather than a manufacturing-focused perspective. In his article, he cites the fashion industry as an example, where Industry 4.0 is presented alongside its components (smart networks, products, and factories) and principles (e.g., real-time, virtualization) to show its impact on the industry, highlighting the role and emergence of technologies. In addition to the fashion industry, there are other studies that address the integration of supply chain management and marketing (Ardito et al., 2018), the impact of certain Industry 4.0 technologies on sales (Syama & Sharma, 2018), and retailing (Esch et al., 2019; Reinartz et al., 2019).

One of the very first publications on Industry 4.0 was published by the consulting firm BCG and addressed the nine key technologies that will be integrated to create the foundation of Industry 4.0. These technologies are big data and analytics, autonomous robots, simulation, horizontal and vertical systems integration, the Internet of Things, cybersecurity, cloud-based systems, additive manufacturing, and augmented reality. These technologies are made integrable by cyber-physical systems (CPS) (Rüßmann et al., 2015). When looking at technologies at the level of international companies, the most important of these are autonomous robots, big data and analytics, additive manufacturing, and the Internet of Things, as these will have the greatest impact on the international role of companies (Strange & Zuchella, 2017).

In their research, Demeter et al. (2020) build the integrative task of CPSs on three core technologies. These are cloud-based technologies, networks, and sensors, and they further distinguish between predominantly virtual and predominantly physical technologies, as shown in Figure 3.

Figure 3: Interconnection of Industry 4.0 Technologies



Source: based on Demeter et al. 2020, p. 15

The emergence and growth of Industry 4.0 at this pace is clearly due to the rise and development of digitalization, which is a kind of Industry 4.0 pre-requisite. Therefore, in order to comprehend how digitalization has changed retailing at the core of Industry 4.0 technologies, it is necessary to examine the effects of these two concepts on industries side by side.

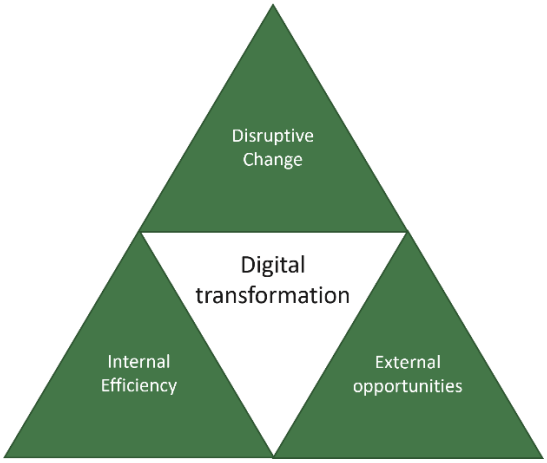
2.1.2 Digitalisation and digital transformation

The rate of technological advancement is being significantly impacted by the growing digitalization of our daily lives. With its emergence, a lot of new concepts have entered our everyday lives and people's minds, but it is important to clarify them. According to Tilson et al. (2010, p. 749), digitalization is nothing other than " a sociotechnical process of applying digitizing techniques to broader social and institutionalcontexts that render digitaltechnologies infrastructural". The development of digital technologies is a precondition for digitalization. "We call digital technologies those that emerge as a combination of communications, computing, and connectivity technologies and fundamentally transform business strategies, business processes, enterprise capabilities, products and services, and key inter-corporate relationships in extended business networks. (Bharadwaj et al., 2013). Digitalization thus creates opportunities to exploit digital advantages, which in many cases also entails business model innovation, in which case we speak of digital transformation. (Autio et al., 2018) Digital transformation is defined as the changes that digital technologies can bring about in a company's business model, resulting in changes to products or organizational structures or in the automation of processes. (Hess et al., 2016). Digital transformation is a strategic renewal process that takes advantage of digital technologies to build capabilities that enable an organization to replace or evolve its existing business model, collaboration approaches, and

organizational culture (Warner & Wäger, 2019). In my dissertation, I will use the aforementioned definitions for digitalization and digital transformation.

Digitalization can impact an organization through digital transformation in three ways (Figure 4).

Figure 4: Impact of digitalization



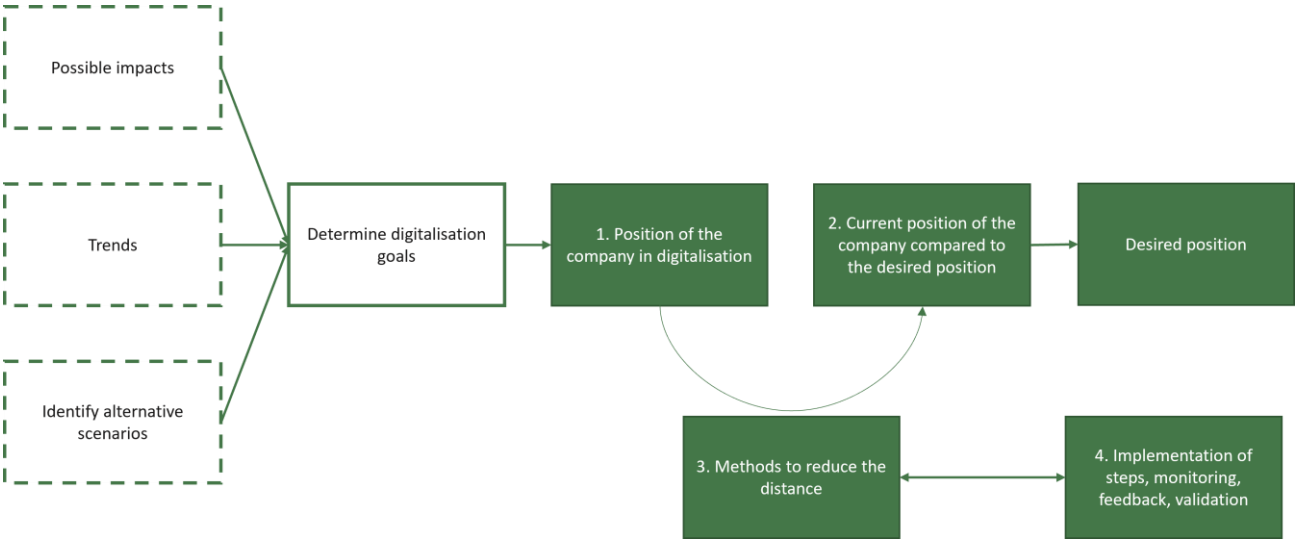
Source: Parviainen et. al 2017, p. 66

1. Internal efficiency: changes in the value chain; traditional supply chains may change
2. External opportunities: new opportunities may arise to meet a customer need or, for example, to maintain and exploit more effective partnerships.
3. Disruptive changes: for example, digitalization completely changes the industry in which the company was previously active and forces it to change its profile completely.

The impact of digitalization extends to the entire value creation system and ecosystem, from individual company value chains to complete supply chains, and thus to end customers. (Kohtamäki et al., 2019).

Digitalization can now affect any organization, and the interconnection of the physical and digital worlds means that manufacturing companies can also become digital, making digitalization one of the foundations of Industry 4.0. The many changes that digitalization has brought are disruptive and thus transform existing industries. New competitors are emerging against established leaders that are able to redefine mature industries, replacing outdated business models with new ones. These days, anything-as-a-service business models are widespread. To put it another way, this means that you can sign up for any kind of online service—software, platform, infrastructure, etc.—that promotes the growth of business networks and ecosystems and makes information more accessible to customers (Rachinger et al., 2019). How can a company address the challenges and opportunities of digitalization? The digital transformation model is designed to answer these questions. This model is presented below, based on Parviainen et al. 2017 (Figure 5).

Figure 1: Digital transformation model



Source: own editing based on Parviainen et al. 2017

1. The first step is to define the company's desired position in the digitalization process. To do this, the following process should be followed:
    1. Identify the potential impacts of digitalization.
    2. Identify the trends that are driving these efforts and determine their impact on the company.
    3. Digitalization alternatives and their impact on the company should be outlined.
    4. The purpose of digitization should be defined.

The second step is to look at the current state of the company and identify how far it is from the desired state, which is already the result of digitization. Step three is to reduce the gap between the desired and the current state and to outline the actions needed to achieve this. Step four is to implement and validate the actions and, if necessary, return to the previous step.

The authors' aim was to outline a generic model suitable for companies in any industry and to address a variety of digitization challenges. Of course, depending on the situation and context, fine-tuning is essential.

2.1.3 Digitalization and retailing

The retail landscape has changed rapidly in recent years, mainly due to the widespread adoption of technologies leading to the era of digitalization and Industry 4.0. The advantage of these emerging new business models is that companies are using and combining the opportunities of digitalization in the processes of retail companies in the right way, making technology a competitive advantage in value creation (Hänninen et al., 2018). In order to maximize synergies, companies need to think both in terms of integrated technologies and processes. This can easily facilitate the shift from multichannel to omnichannel models, which is included in the first element of the new retail framework (Hagberg et al., 2016). (Table 2)

Table 2 Elements of a new retail framework

Element I: Digitization of Exchanges	**Multichannel:** Omnichannel Transformation
	Change communication channels (e.g., mobile devices).
	Increasing use of transactions (e.g., development of self-service technology, mobile payments)
	New forms of distribution (e.g., "click and collect")
Element II: Digitization of actors	Mixing people and digital technologies
	Blurring the boundaries
	Roles and relationships of new actors
Element III: Digitising access	Changing traditional access: home and fixed shops
	New access points: (e.g. pick-up points)
	Mixing access: showrooms
Element IV: Digitisation of supply	Changes in products and services
	Extending the offer
	New forms of pricing

Source: own editing based on Hagberg et al. 2016

The potential of omnichannel shopping—the fact that a consumer can buy a product not only online or offline—is also closely linked to the notion of customer experience and value creation. Omnichannel selling was defined by Verhoef et al. (2015) as the number of available channels and customer touch points to optimize the customer experience and channel efficiency. Berman & Thelen (2018) define these retailer-based synergies with omnichannel marketing. They distinguished four issues. The first is access issues, such as in-store returns after online purchases or notifying customers when a new store opens near them. The second is product information capabilities, which can best help customers choose the right products. The third is cross-selling opportunities, which can take the form of mobile or in-store coupons, targeted emails, etc. The logistics economy, which comes in at number four, is characterized by reduced inventory risk and investment as well as quicker delivery and cheaper warehousing expenses.

From a business model perspective, the potential of omnichannel was identified by Jocevski et al. (2019) (Table 3). They distinguished three main dimensions that have a strong influence on the appropriate business model elements. These dimensions are seamless customer experience, integrated analytics, and efficient supply chain and logistics.

Table 3: Dimensions of omnichannel

Dimensions	Business model element	Business model innovation activity
A seamless customer experience	Contact customers	Deploy in-store technologies that enable better offers and synergies between channels.
	Price quote	They offer services such as click-and-collect and improve the customer experience on mobile devices.
	Key resources	Engage customers through social media and inspire them to become brand ambassadors.
Integrated analytical systems	Price quote	Personal offers and direct services based on data analysis
	Key processes	Developing data analysis skills to improve the customer experience and the efficiency of logistics processes
	Key resources	Internalizing mobile and online stores for a physical store as non-competing resources
Effective supply chain and logistics	Key partners	Develop partnerships with local businesses or invest in physical touch points for transport and return activities.
	Key processes	Develop a network or partnerships that can meet emerging customer expectations.
	Price quote	Investing in technologies (e.g., RFID) that can create new value for consumers

Source: own editing based on Jocevski et al. 2019

Retailers need to consider all channels and all business model dimensions holistically, just like customers, to maximize their perceived value and experience (Savastano et al., 2019). Research on the cost-benefit side of omnichannel systems has been conducted by Berman & Thelen (2018) (Table 4).

Table 4: Cost-benefit elements of omnichannel

Benefit	Cost
Increasing sales due to new channels and tools	Hardware
Higher average sales to existing customers	Software
A higher proportion of customers actually buy	Worker training
Promotional synergies through channels	Additional employee incentives for cross-selling
Lower inventory costs	Other market research expenditures
Reduced delivery costs due to in-store pick-up	Use of cross-channel managers
The lower product return	IT staff

Source: own editing based on Berman & Thelen (2018)

These changes are particularly powerful and beneficial in the fashion industry, where new types of customers are emerging and product offerings are being personalized (Sebald & Jacob 2020). Silva et al. (2020) analyze multi- and omnichannel strategies across nine fashion retailers. (Massimo Dutti, Guess, Tomi Hilfiger, Burberry, Gucci, Celine, H&M, Mango, and Oasis) Their research examined the channels used, in particular the company's websites, social networks, Instagram, YouTube accounts, website integration, and mobile app. They concluded that the level of implementation and integration of the channels used is almost identical across companies, regardless of the segments they focus on. In another study, Macchion et al. (2017) concluded that customers are only willing to buy online from well-known brands that already have physical stores, but this claim now seems to be refuted by the success of some online-only clothing companies.

Many larger retail chains are using more digital tools in their processes and physical stores as a result of these business model changes (Hagberg et al., 2017), supported by technologies like artificial intelligence or robotics.

For SMEs, this level of technology support means lower employment costs but also lower profits, in addition to the current high costs. For this reason, a more likely way for smaller firms to gain a competitive advantage is to build personal bonds between employees and customers (Shankar, 2018; Bertacchini et al., 2017). There are many barriers that can hold back these processes, and these barriers can be weak or strong. Weak barriers may include a few external resources, a low perception of external pressures, and a low intensity of digital services and marketing. Stronger barriers may include a low take-up of digital channels and the will to exploit them. In addition to these barriers, there is also a weak driver, a positive attitude towards digitalization, to facilitate the process (Bollweg et al., 2020).

The organization should also support technological efforts, and employees should see the positive side of it and not see technology as doing their job for them (Bagdasarov, 2018; Priporas et al., 2017). In their model, Frey and Osborne (2017) calculated the potential for automating a total of 702 occupations and concluded that the job of retail salesperson is among the riskiest and one of the easiest jobs to automate. They concluded that these automation opportunities will change the current global labor structure and the supply and demand situation in the labor market.

Technological developments in the provision of retail services also raise new questions about the relationship between retailers and their customers: how do they relate to emerging technologies, and how does this affect their purchasing processes? Successful implementation of technology can increase the value expected by customers, but it can also reduce it if implemented in the wrong way. However, the appropriate use of technology can give a physical store a competitive advantage over online businesses (Nöjd et al., 2020). From this point on, humans interact with both machines and robots, and it is questionable in what way this will influence their behavior (Keeling et al., 2013). For example, which one will they relate to more positively, an anthropomorphic or a humanoid robot? Research by Lu et al. (2019) suggests that anthropomorphic appearance negatively influences consumers, precisely because of the importance of interpersonal relationships. Not only do customers need to accept these technologies, but also the attitude towards the technologies at the top management level is the most important factor before adapting consumer-facing technologies in retail stores (Lorente-Martínez et al., 2020).

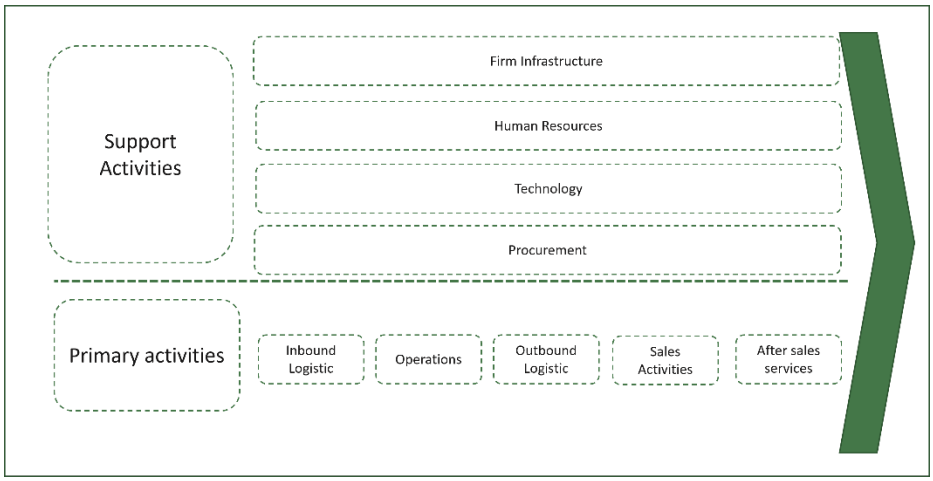
Marketing experts are also facing increasing responsibilities. Today, it is not enough to sell a product to customers. It is becoming increasingly important, in the face of ever-increasing competition, to make customer shopping an experience that increases the likelihood of repurchase, one of the tools for which is the use of digital technologies. In their article, Willems et al. (2017) show how digitalization tools can be used to motivate customers at different stages of the shopping process, and the customer experience plays a key role in this. New technologies allow customers to experience products passively, which contributes to the experience (Lehdonvirta, 2012). Here we can think of software that allows us to see how a dress would look on us from home, and therefore we do not have to go to a store to try it on. However, the availability of digital tools is also widespread within stores, which can influence customer choice, make the shopping experience easier and more enjoyable, and thus have a big impact on value creation. There are several tools that can enhance this impact in store. As an illustration, consider digital product placement (Gustaffsson et al., 2019), electronic shelf labeling (Soutjis et al., 2017), and digital advertising flyers (Ziliani & Ieva, 2015). Retailers are depending much more on mobile technologies in addition to these solutions. Kaatz et al. (2019) studied the shift from desktop to mobile in fashion retail and analyzed three dimensions of this shift: customer-initiated channels, company-initiated channels, and customer experience. According to Bellini & Aiolfi (2019) research, companies can make it accessible for their consumers to check digital shopping lists using mobile technology, call family or friends for shopping information, check promotions on the website, or see an ad in the app. They can also search for product information, compare prices of products by scanning a QR code, visit a merchant's website, use digital coupons, and make payments. These practices can greatly improve customer engagement and experiences. Impulse buying behavior is also enhanced because digitalization helps to make faster decisions and opens up new perspectives (Lidholm et al., 2017). In addition, companies can use it as a data-driven marketing tool to build a mobile-based market infrastructure that contributes to better customer insights (Beauvisage & Mellet 2020). We can see that a particular technology, such as mobile, can completely transform the retail environment (Fuentes et al., 2017). These tools have a major impact on both promotional and pricing models, while also addressing the technical conditions required to support them (Grewal et al., 2017).

The emergence of digitalization technologies in retail stores

The impact of value chains on retailing and its theoretical framework are discussed in detail in the second article, but some conclusions are necessary to justify my choice of topic.

The value chain model was published in Porter's 1985 article. In it, he laid the foundation for the widely known value chain model (Figure 6).

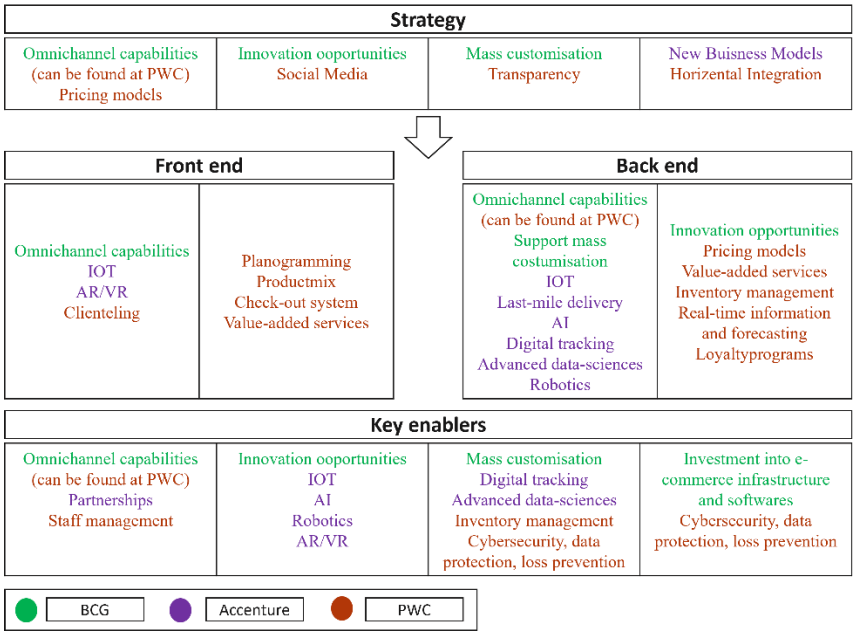
Figure 6 Porter value chain model



Source: Porter 1985

The enterprise value chain model can be divided into two main parts: the supporting activities and the primary (core) activities. Together they are responsible for maintaining the competitiveness of the company and creating value for customers. Support activities include infrastructure, human resource management, technology, and procurement. While primary activities are inbound logistics, processes, outbound logistics, marketing and sales, and services. In order to determine whether digital trends are growing in retail environment we used a value chain approach as the foundation for our model and compared it with the findings of a review of publications on retail digitalization by three prominent consulting firms (Figure 7). We have separated strategic level, front end, back end and the key factors that are essential for implementation.

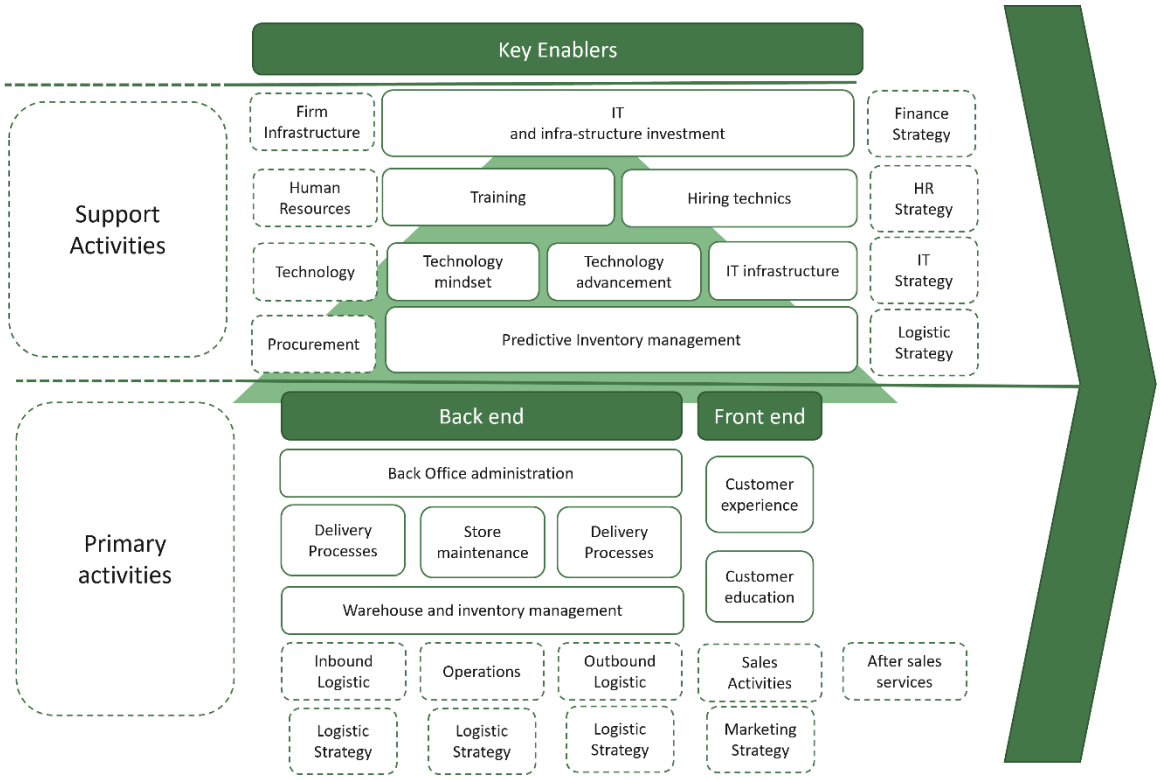
Figure 7 Digitalization trends in retail



Source: Matyusz & Pistrui 2020

As a result of the analysis of the value chain model and the consultants reports, we have developed the following analytical framework, where the impact of certain technologies is placed on the corresponding element of the value chain model, allowing us to examine the impact of each technology on the value chains (Figure 8). For a more detailed methodological and model-related explanation, see Matyusz & Pistrui (2020, p. 32) in the journal Budapest Management Review.

Figure 8: The place of digitalization in the retail value chain



Source: Matyusz & Pistrui 2020

As can be observed in Figure 7, robots can appear in several areas of retail. They can be found in back-end processes, but they can also play a key role and an integrating role in the front-end implementation of other technologies and therefore have great potential for use. This hypothesis will be explored in my article 3 in connection with dynamic capabilities on a global scale. However, it is essential to determine and classify the types of robots present in the retail sector. Unlike industrial robots, which are primarily involved in manufacturing activities, these retail robots offer diverse services to both customers and employees, covering front-end and back-end operations.

The emergence of robotics in retail

Among the Industry 4.0 technologies identified by Rußmann et al. (2015, advanced robotics stands out. According to their research, these industrial robots have distinct characteristics compared to conventional industrial robots that have been used in historical contexts. Specifically, they are characterized by their autonomy, flexibility, and cooperation capabilities. The autonomy of these entities comes from their ability to make decisions by relying on existing algorithms. Flexible because they are capable of multi-tasking and more mobile than their predecessors from generations ago. Cooperative, as they possess the ability to engage in more profound levels of human-robot collaboration. The spread of industrial robots is also due to the fact that they are now seen as an Industry 4.0 technology and not just an example of industrial automation solutions. Thanks to their exponential technological nature, the cost of industrial robots is constantly decreasing, and their technical capabilities are becoming more versatile, which is why they are becoming more widespread. Because of this cost reduction and diverse application, SMEs can nowadays afford to invest in such solutions (Strange & Zucchella 2017). In Pistrui & Harmat (2022), the paper examines how these robots have spread across industries and how this feature is observed in the case of service robots. Furthermore, the third article discusses the potential retail applications of these robots, based on the methodological foundation of content analysis and dynamic capabilities theory.

2.2 My research question

As I mentioned in the introduction, my research question is: What is the influence of digitalization, specifically in relation to service robots, on the worldwide value chain of retail companies? I intend to answer this question with three articles in which me and my co-authors seek answers to the following questions (Figure 9):

1. Defining and applying service robots in business organizations: a systematic literature review

Questions: What is the definition of service robots, how do they participate in the value creation of companies, and where do they fit within the typology of robots? In which industries has their use spread, and why?

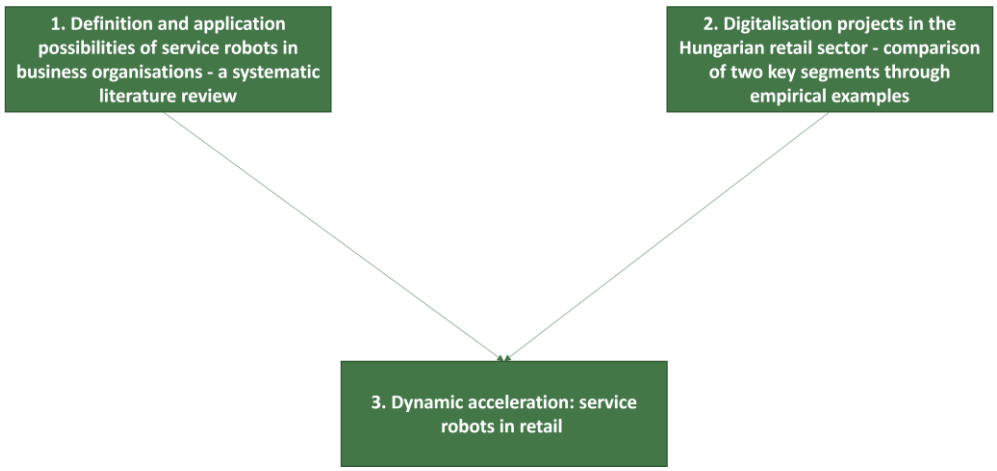
2. Digitalization projects in the Hungarian retail sector

Questions: What are the digitalization trends in retail, how can these trends be framed, and how are companies trying to meet these trends by implementing different digitalization projects?

3. Dynamic acceleration: service robots in retail

Questions: Which types of dynamic capabilities influence the application of service robots in retail, and how can these capabilities contribute towards sustaining competitive advantage in the sector?

Figure 9: Articles used as part of an article-based dissertation



Source: own editing

2.3. Aim and relevance of the research

The aim of this dissertation is to present and analyze the impact of digitalization on retail chains. Describe the impact of technological developments, in the form of the fourth industrial revolution, on their value creation processes.

In recent years, there has been an explosion of research on these effects. Reports from various international organizations have been continuously addressing this issue since the 2015 World Economic Forum in Davos.

The impact of Industry 4.0 technologies on manufacturing is the main focus of research, but it is undeniable that the process, which is associated with the fourth industrial revolution, has cross-industry implications, with widespread impact on the commercial and services sectors, thanks to their explosive growth and falling costs.

Taking the WEF (2018) recommendations as a model, beyond academic relevance, I would like to demonstrate the usefulness of my dissertation for decision-makers, whether they be company or political leaders.

2.3.1 Relevance of the research to higher education in science

My research serves several purposes that benefit academic higher education. Demonstrating how robots can benefit the retail sector will also better demonstrate the integrated impact of the technologies and provide another example of this. By taking a value and supply chain approach and looking at the impact of technologies, I aim to provide a new perspective on Industry 4.0 research that not only looks at the impact of Industry 4.0 on manufacturing but also interprets it as extending to other sectors. In addition, I will highlight that digitalization is no longer just a development opportunity but can also play a risk mitigation role as well as an important factor

for competitiveness, thus opening the way for new research in this direction that can focus on the long-term effects of the pandemic on digitalization.

We must not forget that we must also bring these effects into higher education. After all, automation and robotization will change some jobs; some will disappear and others will be created, but the remaining jobs will require different skills and competences to be successfully filled, and higher education must adapt to this so that students are equipped with the necessary skills to enter the labor market and have the chance to succeed in the business and public administration worlds, not just as employees.

It also illustrates the differences in the global use of certain technologies, as robots are more widely implemented in retail in different areas in different parts of the world. This example well demonstrates the importance of international business economics in education.

2.3.2 Relevance of the research for policy makers

Among decision-makers, we distinguish between policy-makers and practicing business decision-makers. For policymakers, it may be important to recognize that digital technologies have become a precondition for competitiveness and that it is therefore essential for them to ensure support for such developments and to create the infrastructure conditions for their introduction. Development policies must include digital advancements not only in terms of manufacturing technology but also in their capacity to strengthen service sectors, thereby improving the competitiveness of such enterprises. Moreover, it is crucial to acknowledge that these policies can also yield favorable outcomes for a country's overall competitiveness.

On the corporate decision-maker side, my dissertation is, of course, relevant to corporate decision-makers in the retail industry. For them, it is relevant to see how the use of digital technologies in retail can contribute to maintaining their competitive advantage, which technologies and processes they can support, and how these contribute to their value creation, whether on the back end or the front end. It is also important to see that these technologies have a real impact in an integrated way, and I will give you an insight into this through the example of robots. Of course, it is not only in robots that these integrated benefits can be achieved, but their complexity and versatility make them perhaps one of the best examples. This will be helped by learning about the classifications of these service robots and seeing practical examples of their use.

It also highlights the infrastructural and capability factors in which investment is essential for the successful implementation of digital assets, like robots.

2.4 Methodology

The main methods chosen for my thesis is a systematic literature review, case studies, and interviews with companies and experts. However, for my third article, content analysis is also used as a methodology.

2.4.1. Systematic literature review

In the following section, I rely heavily on a presentation by Dr. Shadi Erfani (University of Technology Sydney) at the 2019 PROM Programme International Exchange of PhD Candidates and Academic Staff, a three-day event in Warsaw. Her presentation was based on three main academic papers (Crawford et al., 2015; Erfani & Abedin, 2018; Machi & McEvoy, 2016).

Systematic literature review is a literature review methodology that uses systematic methods to collect secondary data, critically review studies, synthesize qualitative or quantitative results, and help to explore a particular issue from multiple perspectives. The practice of reducing the influence of study errors and biases, identifying areas for potential research gaps, and assuming new results through the synthesis of findings from many studies is beneficial.

There are eight steps to systematic literature processing:

1. Defining the research question
2. Developing an audit protocol: how we will select the literature
3. Identification of relevant studies
4. Pre-selection of studies
5. Evaluation of studies
6. Data retrieval
7. Synthesising and interpreting results
8. Publication and dissemination of results

Due to the many different approaches and researches that exist for both Industry 4.0, digitalization, and robots, a systematic literature review is a suitable method to summarize these researches and thus lay the foundation for exploring the potential applications of robots beyond manufacturing. After all, several studies have already looked at the applications of robots in other sectors, but their synthesis has been limited or nonexistent.

2.4.2 Case studies

At this point, I would like to write a little bit more about the research project **EFOP-3.6.2-16-2017-00007, "Aspects of the development of a smart, sustainable, and inclusive society: social, technological, and innovation networks in employment and the digital economy,"** and the research team I was part of.

Within the EFOP project, we investigated the meaning and implementation of Industry 4.0 in different industries. A case study methodology was chosen to present these. The different industries have been examined in pairs, for example, FMCG, SSC, retail, and others, to show the impact of Industry 4.0. I was part of the team that studied the retail sector, which actually had a big influence on the outcome of my current dissertation.

Two companies were selected, and a case study was written about them. These case studies were used to write the main part of the second article.

According to Harling (2012), "a case study is a holistic study that examines a contemporary phenomenon in its natural context. A phenomenon can be any problem, event, action, or even individual. By natural environment, he means the context of the event, the circumstances in which the phenomenon takes place. This is important when examining a phenomenon because either the environment affects it or they cannot be clearly separated from each other and are therefore highly relevant to the researcher. Holistic analysis ensures the versatility and detail of the data. In collecting data, researchers can rely on observation, interviews, documentary analysis, and audiovisual materials, among others.

In Simmon's (2014) definition, "a case study is an in-depth exploration of the complexity and uniqueness of a project, policy, institution, program, or system from multiple perspectives in a'real life' context."

The case-study method is the right choice when the questions of how and why are to be answered or when the boundaries between the phenomenon under study and the context are not fully separable. Additionally, this method is particularly suitable where there exists an inherent interdependence between the subject of research and its surrounding context, rendering a complete separation of the two entities unattainable. It is imperative that the researcher remain impartial and refrain from exerting any influence on the study's outcome, irrespective of the unfolding events. (Starman, 2013).

Because of its versatility, the case study method is now increasingly referred to as a distinct research concept that can encompass more than just a single method (Starman, 2013; Simmon, 2014).

<u>Interview draft:</u>

In the course of our study, we used a joint interview schedule for the entirety of the EFOP-3.6.2 research project. These interviews were conducted in a semi-structured manner, as our objective was to gain a comprehensive understanding of Industry 4.0 as a phenomenon from the perspective of the interviewees. Our aim was to delve into their experiences and attitudes, as well as to investigate the unique characteristics of the phenomenon within the specific industry under examination. This approach allowed for a more relaxed and informal environment, facilitating the gathering of important insights.

1. Describe the company: what has characterized the market in the last 10 years, what is the market today, and what is expected (business models, customers, products, operational and financial indicators of the company).
2. How would you define what Industry 4.0 is? What does it mean to you? How do you define it? How do you interpret it in your company?
3. How does Industry 4.0 manifest itself in your company? How much are these efforts reflected in the Hungarian unit (or: How much is Industry 4.0 present in your industry? How will your industry look in 5–10 years?

    - Formal expectation at some level—headquarters, owner? Is the shift happening locally?

- Where did the inspiration come from to use the tools of the fourth industrial revolution (internal or external pressure, constraints or opportunities, labor shortages, profitable automation, etc.)? at the company level, at the local level
- Was the use of robots and the drive for automation in the factory common in the past? Since when? (It is likely to be mentioned here that there have been such Industry 4.0 projects in the past.)
- What divisions of your business are the impact of the introduction of Industry 4.0 tools? (production, logistics, purchasing, warehouse, quality, operations)
- What projects have been implemented in relation to Industry 4.0?
- What solutions or tools do you have experience with? What solutions do you consider more suitable in the short and medium term?
- Tell us about one or two previous projects in particular.

    1. Who decides on the project, and on what basis? What is the purpose of the project?
    2. Why these projects were highlighted
    3. who is involved in the project (internal or external; whether it is open to business partners; whether there was an expectation from customers; who is involved internally)
    4. adapted Industry 4.0 tool (out of the box, in-house development, combination)
    5. What kind of investment is involved, how is the return expected, and, in general, what is the expected return on these industries? 4.0 projects are different from other projects.
    6. the steps involved in such a project
    7. results achieved, sustainability of results (whether the results mattered or were driven by other considerations)
    8. general experiences, success criteria, failure factors of the project—participants, leaders, areas concerned, organizational gaps

4. What is the domestic economic environment like for manufacturing companies, and for this factory in particular, in terms of Industry 4.0?
    1. Where do you see strengths? What are they? Does it affect your company specifically?
    2. Where do you see weaknesses? What weaknesses? Does it affect your company specifically?
    3. What changes would you like to see?
    4. Do you have a company that you watch and that you benchmark against? Is there a business-to-business forum you would like to participate in?
    5. How can the university help the company with Industry 4.0?
5. Do you think there are any important issues that we have not touched on?

The interviews for the second article were based on this draft interview. Table 5 shows the EFOP-3.6.2 joint company questionnaire, which was filled out after each interview and used to follow up on whether our questions had been answered. Thus, asking some questions differently over time helps to track changes, which is particularly important in the context of the pandemic, and also increases the issues of validity and reliability.

Table 5: Company Fact Sheet

General information about the company under review	Company name		
	Location/location		
	Project name		
	Project theme		
	Number of interviews		
	Interview subject position 1		
	Interview subject position 2		
	Interview subject position 3		
	Other sources of information		
Project information		**P1**	
	Duration		
	Departments concerned		
	Target		
	Previous exercises		
Costs (m/ft)	Investment cost		
	Operating costs		
	Depreciation/impairment		
	ROI (also interesting if not recorded)		
	Other planned investments		
Competitive advantages and benefits	The impact of I4.0	Positive	Negative
	on costs		
	on quality		
	the reliability of deliverables over time		
	flexibility (e.g., to produce different product versions)		
	speed/processing speed		
	on environmental performance		
	on labor productivity		
	on energy use		
	human resource requirements (full-time)		
	supply chain efficiency		
Contacts	The project supports or challenges the following areas:	Sponsored by	It is a challenge.
	new organizational solutions		
	IT areas		
	Lean		
	Supply chain efficiency		
	International relations		

	Contacts with stakeholders		
	Energy efficiency		
	Innovation		
Human resources	Impact of change (can be both)	Negative	Positive
	the working environment		
	employee satisfaction		
	working relationships between colleagues		
	the control, monitoring, and surveillance exercise		
	knowledge, skills development		
	on fluctuation		
Applied I4.0 technologies	**Data, data analysis, and processing**	Yes	No
	Analysis to support forecasting		
	Predictive maintenance		
	Big data (analytics)		
	An ERP (Enterprise Resource Planning) system that comprehensively integrates internal processes		
	ERP systems integrating buyers and suppliers, digital solutions		
	Simulations (e.g., process optimization, internal layout development)		
	Autonomous systems		
	Driverless transport equipment		
	Robots		
	Autonomous vehicles (e.g., for internal material handling)		
	Drones		
	Automated warehouse		
	Technologies		
	Internet of Things		
	Machine-to-machine systems		
	Cloud computing: applications running in the cloud		
	Artificial Intelligence		
	3D printing		
	Sensors, intelligent sensors		
	Virtual reality		
	Energy storage systems, energy optimization		

Source: EFOP-3.6.2 documentation

2.4.3 Document analysis

Bowen (2009, p. 27) define document analysis as "a systematic process for reviewing or evaluating documents, both print and electronic (computer-based and Internet-delivered)."

Such documents include, but are not limited to, advertisements, handbooks, background documentation, brochures, diaries, journals, event programs, letters and memos, maps, charts, newspaper press releases, organizational or institutional reports, and questionnaire data (Bowen, 2009).

The advantages of document analysis include that it is an efficient and less time-consuming method, much of the material is freely available, it is cost-effective, the research process does not change the content, it covers a broad spectrum, and it is accurate. The disadvantages are that, as they are not produced for research purposes, they may leave out some details that may be relevant to the research. Furthermore, they are difficult to retrieve, as they may have been provided for research purposes only or they may have been deliberately blocked from access. Other drawbacks may be that the selection of data included is subjective, as they have different purposes, so the choice of data may reflect the perspective and purpose of the content producer. These drawbacks can be easily mitigated by introducing other methods, and the advantages make their use widespread among researchers (Bowen, 2009).

The choice of this method is essential for the study of the uptake of robots since fieldwork and observation are out of the question as the technology is less widespread in our country. However, by analyzing materials from large companies and press articles, a comprehensive picture can be obtained.

2.5 Validity and reliability

In simple terms, reliability is the stability of the findings, while validity is the accuracy of the findings (Altheide & Johnson, 1994). Validity and reliability ensure that a study avoids researcher bias, that the data are as accurate as possible, and that the methods themselves are appropriately chosen to produce the most accurate results (Singh, 2014).

According to Mohajan (2017), choosing the right research time horizon, research methodology, and data collection methodology and not influencing the research subjects towards a certain answer is essential to promoting validity. The following options are available to improve validity:

1. Research objectives should be clearly defined and operationalized.
2. Align the measurement with the research objectives.
3. Verification of measurements
4. If possible, compare the results with other similar research.

As I mentioned at the end of the case study chapter, interviewing the same subjects at different times also increases the value of validity and reliability. This is because we can see how the

interviewee interprets certain questions at different times, and possible inconsistencies and misunderstandings can be more easily filtered out. Furthermore, the continuous review of the literature and, thus, the interpretation of the context of the results can help to further increase validity and reliability during the research process. Moreover, the systematic literature processing methodology used for this purpose can also help to eliminate the effects of errors and biases. In the third article, the diversity of methods ensures validity. Furthermore, a complete database analysis of three different geographical areas contributes to ensuring validity.

3. Results

In this chapter, I summarize the articles published so far and publish them without any changes, with the full agreement of the co-authors. I also highlight the links between the articles and justify which other articles were included as a premise for some of them. As I pointed out in the research questions, I base my dissertation on three articles. In what follows, I will highlight the connections between them.

3.1 The articles in my dissertation

In the next phase of my dissertation, I will provide a brief summary of the interconnections and logical associations among the articles, clarifying their relevance to the primary research question by using the sub-questions from the articles and their corresponding answers. Table 6 provides a summary of the publications, organized by research topics, content, and place of publication. Additionally, it acknowledges and emphasizes the contributions of my co-authors, whose involvement was important in conducting this research.

Figure 9: Articles used as part of my article-based dissertation

Main research question	**The evolution of digitalisation with a focus on service robots, how does it enable the successful implementation of technologies in a business environment?**					
Article No	Authors	Title	Sub Questions	Answers	Journal	Classification
1	Pistrui Bence, Harmat Vanda	A szolgáltató robotok definiálása és alkalmazási lehetőségei az üzleti szervezetekben-szisztematikus irodalmi áttekintés	What is the definition of service robots, how do they participate in the value creation of companies and where do they fit within the typology of	Providing a definition for service robots Typology of robots and their occurrence within industries The emergence of effects on retail trade: - Attitude - Distancing - Consumer experience	Budapest Management Review	B
2	Matyusz Zsolt, Pistrui Bence	Digitalisation projects in the Hungarian retail sector - comparison of two key segments through	What are the digitalisation trends in retail, how can these trends be framed, and how are companies trying to respond to these	Impact of digitalisation on value chains Validation and use of a model to demonstrate integrative robot technology	Budapest Management Review	B
3	Pistrui Bence, Kostyal Dániel Stephen, Matyusz Zsolt	Dynamic acceleration: service robots in retail	Which types of dynamic capabilities influence the application of service robots in retail, and how can these	The importance of investing in dynamic capabilities for the successful use of robots Detecting geographical differences in the use of robots	Cogent Business & Management	Q2

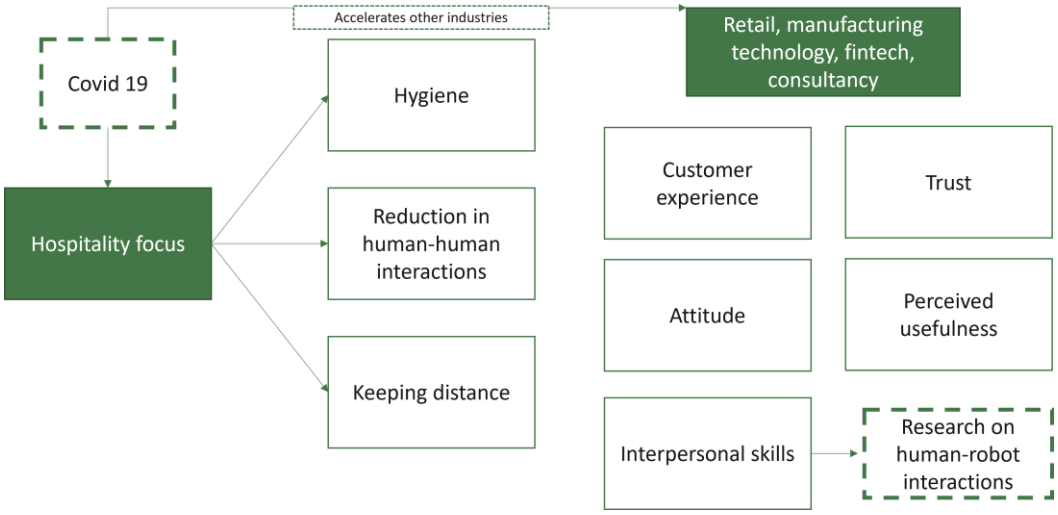
Source: own editing

In the following, I will provide a quick summary overview of my published articles, explaining more about the contribution of each part to the overall contribution of my dissertation.

3.1.1 *Defining and applying service robots in business organisations - a systematic literature review*

In the first article, my co-author and I defined service robots, described their main characteristics and identified the industries in which they are present. The discussion highlighted the phenomenon of robots possessing many functionalities, which arise from diverse advancements in digitalization technology. These robots integrate various technologies to enable their versatility in doing multiple tasks. While the focus of the research is on the tourism and hospitality industry (one of the main sufferers of COVID-19, which is why research in this direction started earlier), several other industries using service robots are mentioned, including retail. From the perspective of my research, the impact of COVID-19 highlights the fact that developments and research on robots have accelerated as a result of the pandemic, as they have provided greater opportunities to provide higher-quality hygiene, reduce human-human interactions, and provide distance control. This acceleration was also true for their use in other industries such as consulting, fintech, manufacturing, and retail. In these areas, their use and research directions have included increasing customer experience, trust, perceived usefulness, improving customer attitudes towards robots, and increasing the intensity of research into human-robot interactions to increase the social skills of robots. Therefore, the primary inquiry revolves around identifying the digitized attributes that hold the highest utility for a retail chain. Specifically, we aim to ascertain which of these features, if integrated into a service robot, can effectively contribute to the aforementioned objectives. Additionally, we seek to understand the impact of ongoing digitization advancements within the retail industry, as these factors play a crucial role in shaping the capabilities of present and future robots operating within retail environments.

Figure 10: Results of the first article



Source: own editing

3.1.2 Digitalisation projects in the Hungarian retail sector - comparison of two key segments through empirical examples

In the second article, we examined the digitalization situation in the Hungarian retail sector with one of my supervisors. For this purpose, we chose semi-structured interviews as methodology and selected two companies as interview targets. The criterion for selecting the companies was to have one company from each of the two leading sub-sectors within the Hungarian retail industry. Thus, we chose a fashion retailer and a sports retailer. Through the examples of these two companies, our aim was to show how these companies use digitalization solutions within the value chain theory, what the main reasons are for this, and what their biggest challenges are. As a result of our research, we found that digitalization solutions have an impact on the entire corporate value chain and fundamentally change the way companies approach certain issues. Examples include the choice of appropriate technology and financing, the selection of human resource and training issues with a particular focus on digitalization skills and development areas, and the rethinking of senior management positions to increase the technology focus. For the core activities, we have also shown that both back-end and front-end processes are affected by digitization solutions. As the establishment of improved working conditions for employees is implemented, the efficiency of corporate management is enhanced. Digitalization tools have proven to be crucial in enhancing the customer experience and generating greater value for customers.

3.1.3 Dynamic acceleration: service robots in retail

In the third article, I looked at the potential for the use of robots in the retail environment and the types of robots that can be successfully implemented in a retail environment. This study examine the possible application of robots in the retail sector, as well as the many types of robots that can be effectively used within this environment. The utilization of robots was employed as a demonstration example to analyze the overall influence of a particular technological advancement on retail businesses. The selection of robots is motivated by their ability to include many technologies including as artificial intelligence, drones, sensors, cloud computing, and the Internet of Things (IoT). Moreover, robots find utility in both back-end and front-end operations, encompassing tasks like warehousing, inventory management, and customer information management. The classifications of robots as defined and differentiated in the first paper were used alongside additional research findings that have been since published. It was observed that dynamic capabilities possess an integrational aspect, which facilitates the integration of various elements such as products, resources, capabilities, and business models within firms. The integration of many components facilitates the development of digital ecosystems and platforms that have the potential to yield sustainable competitive advantage. This study examines the impact of robotic technology on the retail industry through the application of two digital transformation models that incorporate dynamic capabilities. Through an analysis of service robots employed by retail organizations, this study aims to identify the essential dynamic characteristics that allow retailers to maintain their competitive advantage in the increasingly competitive retail market. The retail sector's largest companies are at the forefront of innovation, as they navigate the digital revolution and formulate novel

ways to combat the growing dominance of Amazon, a major player in the e-commerce industry. The implementation of robotic technology in the retail industry has major potential for transforming both front-end and back-end operations. The utilization of retail robots and developing technology provides a deeper understanding of customer behavior, requiring robots to possess improved social competency, human-like personality features, and adaptability. The significance of anthropomorphism and social features of robots is more pronounced in the retail industry compared to other sectors, given that an excessive degree of anthropomorphism has the potential to generate unfavorable perceptions. The effective deployment of service robots has the potential to improve dynamic capabilities and improve digital sensing capabilities. Asian retail stores have demonstrated an important lead in front-end usage of service robots, as the companies in the region have already implemented them in that field. The utilization of robots in both front-end and back-end operations is more evenly distributed in the United States. While, in Europe back-end procedures are predominantly observed in sales-associated warehouses.

4. Summary

In the following section I would like to answer explicitly to my research question, which was: What is the influence of digitalization, specifically in relation to service robots, on the worldwide value chain of retail companies?

Due to technological advancements, improved accessibility, and the influence of the COVID-19 epidemic, robots have experienced a notable increase in their availability to businesses and have expanded their presence across all sectors in order to perform a diverse array of functions. The definition of service robots was imperative in enhancing comprehension of the proliferation of robots beyond industrial applications.

In general, the fourth industrial revolution's effects and the growth of digitalization have had an impact on the retail industry. The integration of digital assets has had a profound impact on every aspect of a company's value chain. The retail business is currently facing new strategic problems, which have required decision-makers to prioritize IT strategy, and IT infrastructure development. Additionally, there is a need to provide sales and human resource management with the necessary skills to train and develop personnel in the area of digital capabilities. The integration of digitalization has been prevalent in various aspects of both back-end and front-end operations, leading to the emergence of numerous technical advancements, such as the utilization of robots within the retail industry.

The introduction of service robots in the retail sector has demonstrated differences throughout different regions of the world. In the European context, these technologies are predominantly employed in backend operations, encompassing tasks such as warehouse automation, inventory automation, and security services. In the Asian region, particularly within the domain of front-end solutions, there has been a notable proliferation aimed at enhancing the whole customer experience. In the United States, their use has been mixed in both back-end and front-end processes. The adaption of dynamic capabilities is expected to enhance the probability of effective integration of robotic technologies into organizational processes, thereby leading to an increased competitive advantage.

Further areas of research could encompass a comprehensive exploration of technologies beyond robotics, in order to enhance the credibility of a broader research that bolsters the connection between technologies and dynamic capacities.

However, the extent to which robots will become commonplace companions in the retail industry is yet to be determined, while the possibility for such integration exists.

In conclusion, it is essential for the successful implementation of digital tools that the right infrastructure is in place and that companies have the resources to ensure that it is up-to-date. Robotic technology is only one of a number of possible advanced technologies that can provide a competitive advantage over competitors today, but it can quickly become a prerequisite for staying competitive. They are having an impact on both back-end and front-end processes and are having an impact on the entire enterprise value chain. The importance of their role in back-end processes will presumably remain, but an interesting further research question may be: how sustainable is their role in the front-end in the long term? To what extent can they be a means

of creating a long-term customer experience, or are they just one-off hype that, once seen, can no longer have an impact?

5. Acknowledgements

I would like to thank my supervisors, Dr. Erzsébet Czakó and Dr. Zsolt Matyusz, for always being critical but supportive and helping me to produce the highest quality work. To my co-authors for the great and enjoyable work we have done together. To my teachers and colleagues for all their professional advice, and to my family and friends for their moral support along the way.

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Annexes

Annex 1 Defining and applying service robots in business organisations - a systematic literature review

Abstract

Service robots are able to perform increasingly sophisticated tasks, both in terms of physical and cognitive activities. According to predictions, 85% of consumer interactions will not involve human employees by 2025, which supports the growing demand for them globally. The introduction of service robots is thus becoming more common in various industries. The aim of this article is to define service robots and review their application possibilities, for which we conducted a systematic literature search. In our article, after the introduction, we present the method of literature research, then define the concept of service robots by synthesizing the definitions found in the reviewed literature, and summarize the jobs that can be filled by service robots and the tasks they can perform.

Keywords: service robot, robot workforce, robot worker, Fourth Industrial Revolution, Industry 4.0

Introduction

Service robots can perform increasingly sophisticated tasks, both in terms of physical and cognitive activities (Lu et al., 2020). Demand for them is growing globally, supported by predictions that by 2025, 85 percent of consumer interactions will be without human workers (Schneider, 2017). While the robotization phenomenon was previously mostly concentrated in the industrial environment, today the use of service robots is also emerging in a growing number of areas (Writz et al., 2018; Marciniak, Móricz, & Baksa, 2020), including prominently in the tourism and hospitality sectors. At the Mandarin Oriental Hotel in Las Vegas, a humanoid Pepper robot greets and informs guests (Walsh, 2018), and the Henn na Hotel in Japan is the first hotel in the world to have a robot staff, where guests can choose to check in with an android female or a dinosaur robot upon arrival (Kikuchi, 2018). Service robots have also appeared at airports, providing information to passengers and performing maintenance and security tasks (Paluch, Wirtz, & Kunz, 2020). In addition to tourism, service robots are also being used in the healthcare sector, where the need has been driven by labor shortages and an aging population. At the Shintomi nursing home in Tokyo, robots help move patients and entertain them as conversation partners (Foster, 2018).

As discussed above, it can be seen that service robots can perform many tasks. The purpose of this paper is to define service robots and review their applications, for which a systematic literature review has been carried out. It is important to note that we focus on an overview of the jobs that can be performed by service robots. The service robot workforce with a high level of social skills in health care and therapy is not the subject of our present study.

In this article, following the introduction, we will place robots in the context of the ongoing phenomenon by presenting the Fourth Industrial Revolution and the context of Industry 4.0, as well as the conditions and characteristics of the technologies involved. We will focus on the robots used in the Fourth Industrial Revolution, and within that, we will narrow our research to service robots. Then, after the introductory section, we present the methodology of the literature review, which mainly takes into account the recommendations of Okoli & Schabram (2010). In

the results section, we define the concept of service robots by synthesizing the definitions found in the literature review and summarize the industry emergence of service robots and the jobs and tasks they can perform.

Fourth Industrial Revolution and Industry 4.0

The term 'fourth industrial revolution' was first used by the World Economic Forum (WEF) in 2016 to describe the changes taking place in the industrial and digital worlds. Also in that year, the WEF published Klaus Shwab's book "*Fourth Industrial Revolution*" (Karabegović, Husak & Predrag, 2019), which is often referred to by researchers on the topic. In Schwab's definition of the fourth industrial revolution, individuals move between digital and offline spaces while using connected technologies to manage their lives (Miller, 2016).

The Fourth Industrial Revolution is characterized by the interconnection of technologies, blurring the boundaries between the physical, digital, and biological spheres (Xu, David, & Kim, 2018). The Fourth Industrial Revolution is accelerating exponentially (Karabegovic, 2017) and is affecting almost all industries in all countries. The breadth and depth of the changes brought by the fourth industrial revolution will lead to a transformation of the entire production, management, and governance systems (Schwab, 2015, cited in Xu, David, & Kim, 2018). Industrial revolutions are understood as a phenomenon affecting the whole economy and society as a whole, while Industry 4.0 is specifically a manufacturing sector-oriented approach that is part of the fourth industrial revolution from a technological perspective (Demeter and Losonci 2020). Losonci, Takács, and Demeter (2019, p. 190) define Industry 4.0 as "building on technological opportunities, Industry 4.0 offers a unique product with digital service content, organizing a new value chain". In our article, we want to examine service robots from this technological perspective and describe their place in current business processes.

Emerging (exponential) technologies

The concept of emerging (exponential) technologies, which has no generally accepted definition, appeared in the literature in the 1980s but became more widely used in the mid-1990s. In this paper, we use Rotolo-Hicks and Martin's (2015) definition of radically new technologies that are relatively fast-growing, that may exhibit a degree of coherence over time, and that significantly affect socio-economic actors, but whose most significant impact will only be felt in the future, making this developmental stage still uncertain and ambiguous. The above formulation is built around the characteristics of emerging technologies: radical novelty, relatively rapid growth, coherence, high impact, uncertainty, and disruption. Halaweh (2013) highlighted uncertainty and the impact on economic and social actors in relation to exponential technologies, but also highlighted other characteristics:

1. Uncertainty: uncertainty has an impact in many areas (e.g., costs, business models, application areas). Over time, uncertainty factors diminish as more areas use these technologies.

2.*Network effect*: As more individuals use an emerging technology, its value rises simultaneously.

3.*Cost*: Having technology is expensive, and so is switching from a developed technology to a new one.

4.*Unclear impact*: Prior to or in the early stages of technology use, the effects of social and ethical shifts were unclear.

5.*Accessibility*: in general, a technology can only be exploited in a certain area, or within a certain country that has developed it.

6.*Under-researched and under-researched*: there are still a few scientific studies about this topic.

Exponential technologies can be categorized according to several criteria. IT research firm Gartner categorizes technologies according to business impact (expected benefits), expectations, and time to general use (Gartner, 2017). WEF (2018) identified 12 emerging technologies (*Table 1*) that will impact future manufacturing technology or completely transform existing systems. As can be seen, robotics and artificial intelligence are among the emerging technologies.

Table 1: Emerging technologies

Artificial intelligence and robotics	Energy collection, storage, transmission
Ubiquitous connected sensors	New computing technologies
Virtual and augmented reality	Biotechnology
Additive manufacturing technologies	Climate Engineering
Blockchain and distributed ledger technology	Neurotechnology
Advanced raw materials and nanomaterials	Space technology

Source: own editing based on WEF (2018)

The concept and typology of robots

According to Kerr (2014), a robot is a mechanical or virtual intelligent agent that performs tasks automatically or under control, usually remotely. The definition of mechanical robots has been addressed by several researchers and international organizations in recent years. Their work was standardized according to ISO standards by Estolatan et al. in 2018. According to the authors definition, a mechanical robot is a reprogrammable multifunctional control unit designed to move objects according to programmed motions to perform various tasks while collecting information about its environment to which it responds intelligently.

Robots can be classified according to several criteria. Estolatan et al. (2018) propose three perspectives to categorize robots: *technological*, *industrial use*, and *interactivity*. According to the *technological perspective*, there are three additional essential characteristics that define a robot. The first is perception, i.e., the technology that enables the robot to interpret the outside world. The second is intelligence, i.e., the algorithm, program, and drive system on which it operates. And the third is movement, which distinguishes robots according to the direction and type of movement that the robot arm and wrist can perform.

The *industrial application* perspective distinguishes robots according to the purpose of their application, which can be divided into industrial and service robots. The main difference between industrial robots and service robots is that service robots cannot be used for industrial automation (ISO 8373, 2012). A service robot is defined as performing a useful task for humans,

"operating in a semi-autonomous or fully autonomous manner to contribute to the well-being of humans, excluding manufacturing activities" (IFR). Industrial robots can be further classified according to their movement, and service robots according to the context of their application. There are three basic components of industrial robots: the manipulator, the controller, and the tool (Singh & Sellappan, 2013). The manipulator consists of the arm and the base of the robot, and it is also where the power supply is located. The manipulator is the unit responsible for the robot's motion. The motion of industrial robots can be described by their relationship to the coordinate system. This can be cylindrical, spherical, anthropomorphic, or descartesian (International Federation of Robotics, 2016). The controller is what makes the robot special, as it enables the technician to set it up to perform the task at hand and then reprogram it, thus creating the possibility of versatility. The tool is the device on the robot that performs the task programmed into the controller, whether it is grasping, painting, sanding, etc. Different tasks require different tools, of course, but these tools ensure that the robot can perform the different tasks in practice (Singh & Sellappan, 2013).

In the case of service robots, we can distinguish between personal service robots (personal SR) and professional service robots (professional SR). Professional service robots perform their tasks in a business environment (e.g., transport robots, rehabilitation robots), as opposed to personal service robots (robotic vacuum cleaners for home use) (Estolatan et al., 2018).

Table 2: Typology and application areas of industrial and service robots

INDUSTRIAL USE	**Category**	**Apply at**
industrial robot	linear robots	laser welding, sealing, pressure, plastic injection moulding
	SCARA robots	assembly, packaging
	articulated robots	painting, packaging, metal casting, palletising, welding
	parallel robots	picking and placing, assembling, handling
	cylindrical robots	medical robots
	other	hazardous environmental operation, underwater, atmospheric, space, use
	unclassified robots	automatic guided vehicles
service robot	personal	household
	professional	business environment

Source: own editing based on Strujik (2011) and Estolatan et al. (2018)

In terms of *interactivity, the* grouping is based on the role of the robot alongside the human. From this point of view, the robot can be distinguished as an assistant, whereby the robot assists the human, but in this case there is no joint work. The second group includes collaborative robots (cobots), which act as a partner to humans in joint work since they work with humans on the same task. And finally, the third category is made up of autonomous robots, which do not require constant human supervision to perform their tasks and therefore do not require human intervention.

In addition to the previous categorization aspects, it is also important to highlight the possibility of categorizing robots according to their appearance (physical characteristics). Robots can be physical embodiments or virtual entities. The latter include software robots used in robotic process automation and chatbots. Physically embodied robots can resemble animals (animoid)

or humans (humanoid) in appearance. Humanoid robots have limbs and a head. Android robots are even more human-like, with silicon skin and artificial hair. A geminoid is a humanoid robot modeled on a living human.

In our research, we focus on the professional use of service robots in a business environment, as shown in Table 2.

The method of literary research

In order to define service robots and review their scope, we conducted a systematic literature review, which Fink (2005, p. 3, p. 17) defines as "systematic, explicit, comprehensive" and a replicable literature search method that aims to identify, evaluate, and synthesize the writings of researchers, academics, and practitioners (Okoli & Schabram, 2010, p. 4). A systematic literature review follows a set of rules that are crucial to conducting a professional, transparent, and reproducible literature review. In order to achieve our research objectives as stated in the introduction, we followed the methodological recommendations of Okoli & Schabram (2010, p. 7), who identified eight steps for conducting a systematic literature review (*Table 3*).

Table 3: Steps in a systematic literature search

1. Definition of the research objective
2. Description of the research protocol
3. Detailed description of the search strategy
4. Description of the selection criteria
5. Evaluation of the quality of the selected studies
6. Analysis of the selected articles
7. Writing the review

Source: own editing based on Okoli & Schabram (2010, p.4.)

Data collection - search strategy

The literature search was conducted in the SCOPUS database using the keyword *"service robot" on November* 13, 2020. For the filters, we set the publication appearance to include English-language journal articles published between 2016 and 2020 in the results list. We also narrowed down the search to *Business Management and Accounting and Social Sciences,* bringing the total number of hits to 76. The focus of our research was on robots in business, so their impact on society in various service industries is not negligible. For this reason, the Social Sciences criterion was selected, although this also included, for example, behavioral science articles in the first round of abstracts. However, several articles related to the social acceptance of robots were also highlighted, which allowed us to look at their use by industry. Various economic modeling robots and banking stock exchange robots were not the focus of our study because their mechanics, operating principles, and relationship to social interactions with humans are different from the service robots we looked at (predictions based on algorithms and historical data, for example). A further research limitation in data collection was that several specific industry studies do not specifically address the classification of robots, referring to both service and industrial robots as generic terms for robots. This is a difficulty in the current research and should be taken into account in future industry-specific research.

Selection criteria

Table 4 shows the criteria for selecting journal articles for review. Journal articles considered relevant to the research should be closely or partially related to the research objective. Closely related (CR) articles are characterized by the fact that they list various definitions of service

robots and discuss some of their applications. Partially related (PR) studies have at least one of the previous criteria. The number of non-related (NR) studies can be divided into several groups: the search resulted in publications that focused more on the technological implementation and did not focus on specific business applications, while other papers did not meet the business criteria for discussing the application of service robots (military, medicine, psychology, etc.). In addition, the search also resulted in articles that only mentioned service robots.

Table 4: Selection criteria for journal articles

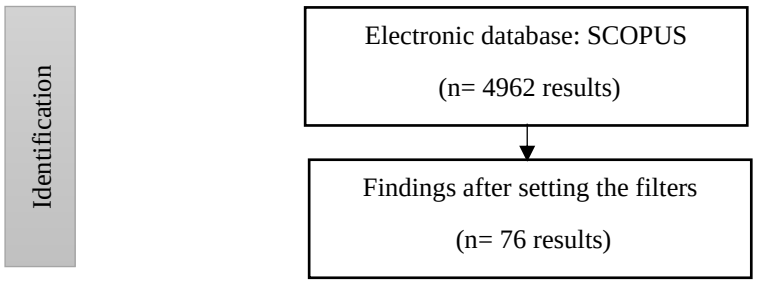
Criteria	Description of the criterion
Closely related (CR)	The definition of a service robot is displayed. *and* The scope of the service robot is shown.
Partially related (PR)	The definition of a service robot is displayed. *or* The scope of the service robot is shown.
Not related (NR)	It does not contain a definition of a service robot. *or* It does not display the application areas of the service robot. *or* Robots are not used for commercial purposes (e.g. warfare, medicine)

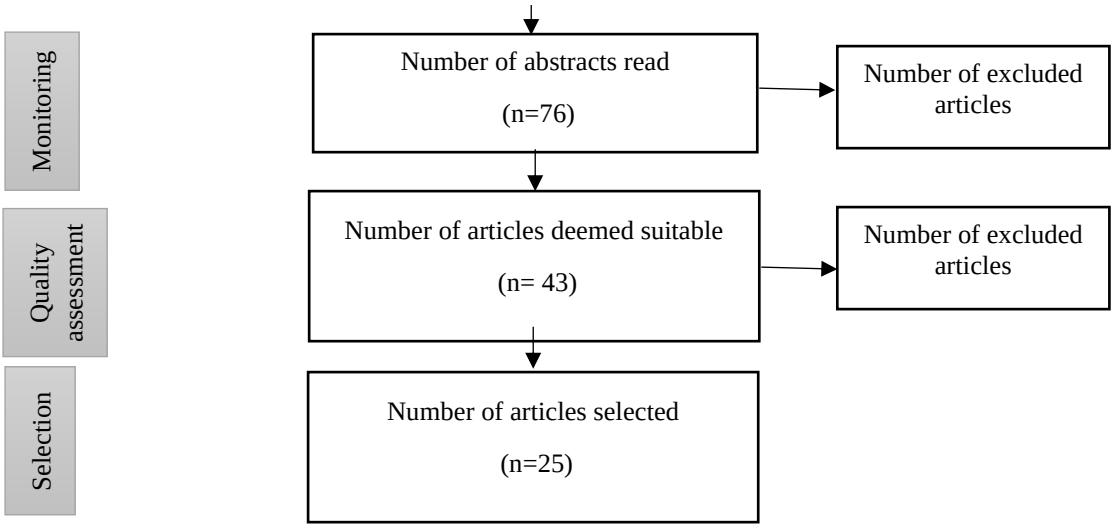
Source: own editing based on Liao et al. (2017, p.3611.)

The article selection process

Figure 1 shows the process of selecting the articles analyzed in the research. The SCOPUS database contains 4962 publications for the keyword "service robot". After adjusting the filters, the number of articles was reduced to 76. 33 papers were eliminated as a result of the selection criteria being applied in the abstract evaluation. Based on the abstracts, 43 articles were considered eligible, which were re-applied to the selection criteria, and a further 18 articles were excluded. Thus, as a result of the systematic literature search, a total of 25 journal articles were included in the analysis.

Figure 1: PRISMA flowchart for the selection of journal articles





Source: own editing based on Gallagher, Kadokura, Eckert, Mounier-Jack & Ross (2016, p.4.)

Results

Descriptive analysis

This chapter presents a descriptive analysis of the selected articles. A total of 25 journal articles were included in the literature review, the distribution of which is shown in *Table 5.* The table shows that the highest proportion of studies on service robots were published in the fields of tourism and hospitality. It can be seen that in addition to the tourism and hospitality-focused journals and articles, there are also service, marketing, and organizational-focused journals. In the coming period, due to the large number of conference papers, further articles are expected to appear in industry-themed journals, but for the foreseeable future, articles on service robots in tourism and hospitality will continue to dominate.

Table 5: Articles included in the analysis by place of publication

Journal	Number of articles
International Journal of Contemporary Hospitality Management	5
International Journal of Hospitality Management	3
Current Issues in Tourism	2
Electronic Markets	1
Service Business	1
Journal of Service Management	2

The Service Industries Journal	2
Technology in Society	2
Journal of Tourism Futures	1
Annals of Tourism Research	2
Journal of Services Marketing	1
Organizational dynamics	1
Industria Textilia	1
Industrial Management and Data Systems	1

Source: own editing

The distribution of the articles analyzed by year is shown in *Table 6.* Eighty percent of the chosen journal articles were released in 2020, amid the global crisis brought on by COVID-19—a topic that will be covered in greater depth at a later time. In the years before 2020, only a few articles specifically aimed at defining and classifying service robots were published. This observation also highlights the presence of research gaps within the field of robotics during the era of the fourth industrial revolution. However, it is important to note that we have currently reached a critical juncture in this regard. This indicates that it is essential to give close attention to service robots.

Table 6: Distribution of selected articles by year of publication

2016	2017	2018	2019	2020
0	2	1	2	20

Source: own editing

Content analysis

Defining service robots

Table 7 summarizes the service robot definitions that emerged as a result of the literature review, some of which are highlighted in this section. Belanche, Casaló, Flavián, and Schepers (2020a) define service robots as autonomous technologies that can be applied to frontline tasks and have some kind of physical interface. According to Lu, Cai, and Gursoy (2019, p. 37), a service robot is defined as a robot capable of making autonomous decisions based on data obtained from its sensors, which allows it to adapt to different situations. In Cha's (2020) definition, the application of a service robot is to support humans through social interaction.

In addition to the definitions of service robots, the reviewed literature revealed various classifications. In their article, Chiang & Trimi (2020) distinguish between professional and personal service robots. Professional service robots are used in companies to increase efficiency and productivity (Calderone 2019; Lee et al. 2009), whereas personal service robots provide assistance to individuals (Darling 2012; Reiser et al. 2009). Lu et al. (2019) typify service robots based on their physical appearance, according to which service robots can be either physically embodied robots or virtual agents. Physically embodied service robots are largely humanoid robots, i.e., they are built like humans and perform mostly cognitive-analytical or emotional-

associative tasks. Virtual service robots include chatbots used in customer service, banking, and tourism, among others.

Most authors have taken the definitions of the International Federation of Robotics and the International Organization for Standardization as a starting point, but several have drawn from the work of Wirtz et al. (2018). Of particular interest is that the latter have used relatively recently published articles as a basis for their definition.

Table 7: Service robot definitions presented in the reviewed journal articles

Author	Author of definition presented	Elements of definition
Belanche, Casaló, Flavián & Schepers (2020a)	Interantional Federation of Robotics (2016)	(1) To carry out activities that benefit people, (2) excluding industrial automation applications.
	Wirtz et al. (2018)	(1) System-based, autonomous and adaptable interfaces. (2) They interact, communicate and provide services to consumers.
Cha (2020)	Ivanov et al. (2017)	(1) Supporting people through social interactions.
Chiang & Trimi (2020)	Haidegger et al. (2013)	(1) Mechanical devices. (2) They imitate human behaviour. (3) They operate autonomously or semi-autonomously. (4) They provide a service to people. (5) They differ from industrial robots in their appearance and functions. (6) It is used to automate repetitive, difficult, complex, dirty, dangerous and time-consuming tasks. (7) Types: professional and personal service robots.
	Interantional Federation of Robotics (2016)	
	Lechevalier et al. (2014)	
	Calderone (2019)	
	Matarić (2017)	
	Lee et al. (2009)	
	Darling (2012)	
	Reiser et al. (2009)	
Lu, Cai & Gursoy (2019)	Writz et al. (2018)	(1) AI-based service agents.
Reis et al. (2020)	Bowen & Morosan (2018)	(1) Physically embodied artificially intelligent agent (2) They affect the physical world (3) Support for core activities
	Kachouie's et al (2014)	

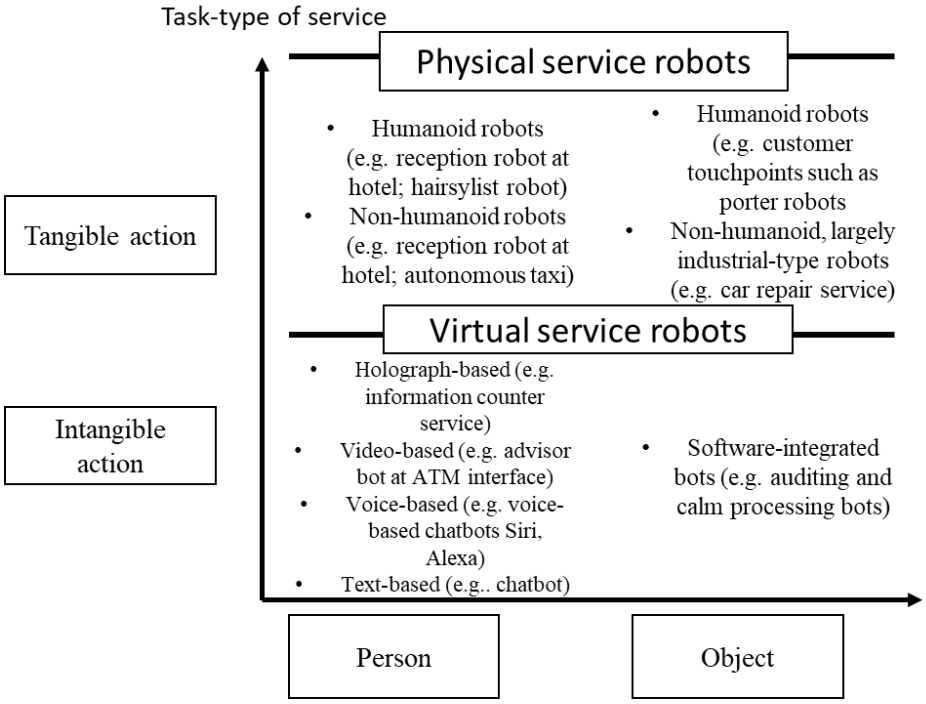
Rosete et al. (2020)	Kuo, Chen, Tseng (2017) Engelhardt (1990)	(1) Smart, programmable devices (2) They sense, they think (3) Helping people
Shin & Jeong (2020)	International Federation of Robotics, 2016 Tung and Law, 2017	(1) They perform useful tasks for people or equipment (2) excluding industrial automation applications
Tung & Law. (2017).	Interantional Federation of Robotics (2016) Dautenhahn, 1999	(1) carrying out activities that benefit people (2) excluding industrial automation applications (3) robots and humans recognise and interact with each other
Tussyadiah, I. (2020)	International Organization for Standardization, 2012 International Federation of Robotics, 2016 Colby, Mithas & Parasuraman, 2016	(1) carrying out activities that benefit people (2) excluding industrial automation applications (3) Have a degree of autonomy (4) Perform the task without human intervention (5) Control by a computer rather than a person
Writz et al. (2018)	Allen et al., 2000 Pagallo, 2013 Singer, 2009 van Doorn et al., 2017	(1) Carry out a series of complex activities (2) Independent decision-making by perception (3) Adapt to situations based on previous experience (4) They act as social robots in cutting-edge applications (5) They can make users feel like social entities
Xu, Stienmetz & Ashton (2020).	International Organization for Standardization, 2012	(1) They perform essential tasks for people (2) They have a degree of autonomy (3) They do the job without human intervention

Source: own editing

Based on the definitions analyzed in the systematic literature review, we can conclude that those physical or software robots with a high level of artificial intelligence and social capabilities, which differ in appearance from industrial robots, are called service robots, which support humans with their activities. Software robots have artificial intelligence and some degree of autonomy, but software robots that suffer from a high lack of social capabilities are not

considered service robots. Wirtz et al. (2018) investigate the impact of service robots on macro (society), meso (markets), and micro (companies, consumers, and workers) environments. In terms of the embodiment of robots, he distinguishes between virtual and physical service robots, between tangible and intangible services based on the task performed, and between humans and objects in terms of the recipient of the services. These representations are summarized with examples in *Figure 2.*

Figure 2.Differentiation of service robots by task type and service recipient



Source: Wirtz et al (2018)

Jobs that can be performed by service robots

Frey and Osborne's 2017 article discusses the likelihood of automating different jobs, which he links to the commercial availability of robots with the autonomy, flexibility, and efficiency to do so. The literature review has revealed potential applications for service robots, which include banking (Belanche et al., 2020a; Castillo et al., 2020), tourism-catering (Lu et al., 2019; Belanche et al., 2020; Cha, 2020; Chiang & Trimi, 2020; Choi et al., 2020; Ho et al., 2020), transport (Chiang & Trimi, 2020), customer service, and retail (Belanche et al., 2020a; Castillo et al., 2020). *Table 8* illustrates the jobs that service robots can perform.

Table 8: Jobs that can be performed by service robots

Job title/task	Author
▪ financial advice	Belanche, Casaló, Flavián & Schepers (2020a) Castillo, Canhoto & Said (2020)
▪ assistance with opening an account, lost credit card	
▪ fintech support	Castillo, Canhoto & Said (2020)

▪ package assembly	Belanche, Casaló, Flavián & Schepers (2020a) Castillo, Canhoto & Said (2020)
▪ airport information	Chiang & Trimi (2020)
▪ customer service	Choi, Oh, Choi & Kim (2020)
▪ consultancy, sales, reservations	Ho, Tojib & Tsarenko (2020)
▪ waiter	Belanche, Casaló & Flavián (2020b) Choi, Oh, Choi & Kim (2020)
▪ cleaning	Choi, Oh, Choi & Kim (2020) Belanche, Casaló & Flavián (2020)
▪ receptionist	Ho, Tojib & Tsarenko (2020), Shin, H. H., & Jeong, M. (2020)
▪ concierge	Choi, Oh, Choi & Kim (2020)
▪ chef	Choi, Oh, Choi & Kim (2020)
▪ barista	Lu, Cai & Gursoy (2019)
▪ luggage rack	Lu, Cai & Gursoy (2019)
▪ food courier	Cha (2020)
▪ room service	Choi, Oh, Choi & Kim (2020)
▪ assisting in the textile industry	Yanhui et al. (2020)
▪ physical distancing in tourism	Seyitoğlu & Ivanov (2020b)
▪ turinform (tourist guides, general information service)	Tussyadiah (2020), Tussyadiah, Zach, & Wang (2020)
▪ information service in hotels, retail shops; order taking in restaurants	van Pinxteren (2019) collection

Source: own editing

Based on our research, we can conclude that the most widespread research currently focuses on service robots in tourism and hospitality. Several explanations are attributed to this in the literature. Not coincidentally, most publications were published in the year 2020. The uncertainty caused by the coronavirus has deeply affected the entire tourism and hospitality sector, so the need to reduce distancing, hygiene, and human-human interactions has put this industry at the center of research on service robots (Seyitoğlu & Ivanov, 2020b). Accordingly, social impact and trust have also become a focus, as more and more people will interact with robots either during their travels or their everyday shopping (van Pinxteren et al. 2019, Tussyadiah, Zach, & Wang 2020). Consumer attitudes are the most important element in the adoption of robots, which will be most influenced by perceived usefulness and perceived value (Zhong et al., 2019). As trust increases, the consumer experience will become of higher quality. However, for some types of services (healthcare) or certain consumer characteristics (anxiety), robots need to be better equipped with social capabilities (van Pinxteren et al. 2019). This has led to an increasing focus on research specifically based on human-robot interactions (Tung & Law 2017).

Summary

The focus of this article was on robots as the defining technologies of the fourth industrial revolution, with a particular emphasis on service robots. In our literature review, we first defined the fourth industrial revolution and exponential technologies, given that modern industrial and service robots can be understood as emerging technologies of Industry 4.0.

In defining service robots, we have sought to show their clear separation from industrial robots. The use of service robots in an industrial environment was also the subject of our article, in order to lay the foundations for more focused future research.

The implementation of service robots in a business environment has started. At present, its greatest impact is in tourism and hospitality, but research shows that it is also likely to spread to retail, banking, healthcare, elderly care, and transport. As companies strive for cost-effective service excellence, the adoption of AI-enabled service robots is expected in most business models (Wirtz 2020). Several studies also focus on human-robot interactions, putting acceptance, trust, and customer experience at the center of attention. From a managerial perspective, the co-existence of employees and service robots allows hospitality companies to leverage the strengths of humans and robots while offsetting their disadvantages (Seyitoğlu & Ivanov 2020a).

Limitations of the research and further research directions

Most of the current research focuses on tourism and hospitality, which allows limited conclusions to be drawn about service robots. However, this research also covers the increase in consumer experience, hazard avoidance, and the subsequent amplification of value generation within the domains of tourism and hospitality. (Seyitoğlu & Ivanov 2020b-c). Further research in other industries would be worthwhile, as the impact of COVID-19 has strongly affected not only tourism and hospitality but also the above-mentioned industries. Automation with robotization and digitalization in general could be an answer to many problems in the above-mentioned industries, as some examples are mentioned in our paper. Several domestic studies have already addressed the emergence of robots, including in service centers (Marciniak, Móricz, & Baksa, 2020) and their penetration in retail (Agárdi, 2018). However, these studies did not focus on service robots but rather on their emergence as a result of digitalization.

However, the difficulties and challenges that the spreading of service robots will bring in terms of strategy planning, human resource management, and supply chain management should not be overlooked, and research into these is definitely needed in the future.

Exciting questions may be: if service robots are to be deployed in both industry and services, what industry specificities may emerge for their application, what roles they may play in companies value chains, and to what extent the development of value chain support activities will be required for successful implementation of robots.

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Annex 2: Digitalization projects in the Hungarian retail sector - comparison of two key segments through empirical examples

Abstracts

One of the most important worldwide trends of our day, digitalization has a profound impact on many facets of daily life and has completely changed the retail industry. The authors' research focuses on retail digitalization trends, how they might be conceptualized, and how businesses are attempting to adapt by putting various digitalization projects into place. As a result, business leaders need to think much more broadly about the role and impact of IT than they have in the past. Additionally, preparing back-end operations for effective front-end digitalization may be a necessary prerequisite for effective front-end digitalization, even though digitalization is an important component of companies strategies and they have the key enablers to achieve this.

Keywords: **industry4.0, digitalization, retail, value chain, fashion, sport**

1. Introduction

Digitalization is one of the most significant global processes of our time, involving many aspects of everyday life. It is also affecting the retail sector and could fundamentally change the way it is structured. The retail sector is one of the most important sectors of the economy, and researchers have seen great potential in the changes to e-commerce brought about by the Internet since the late 1990s (Bakos, 2001). Retailers are increasingly providing digital services to their customers and are also using digitalization to provide better service to customers. The impact of digitalization on retailing is not new, but its impact has intensified today. The advent of the internet has changed business opportunities, business models, commercial formats, and purchasing processes, and it has transformed local shops into part of global commerce. The concept of digitalization encompasses several things. It can mean the process of transforming something into a digital form. In English, it can be understood as "digitalization" (Merriam-Webster, 2020) and "digitization" (Gartner Glossary, 2020a). It can also mean the application of digital technologies to change the business model, creating new revenue and value opportunities ('digitalization', Gartner Glossary, 2020b). In the commercial industry, digitalization is primarily used to refer to e-commerce, but it is recognized that the term has long since outgrown this. Companies are now using digitalization to facilitate their day-to-day work, win over customers, and retain them. It is precisely for this reason that there is a need to address digitalization on a much broader scale and to examine its impact on both the value and supply chains (Hagberg, Sundstrom, & Egels-Zandén, 2016).

There are two main reasons why traders are being forced to adopt digital technologies. One reason is that customers value a company that is equipped with the benefits of digitalization, and the other is that they need to exploit these benefits to change their business processes (Mäenpää & Korhonen, 2015). Several studies have already shown the impact of today's digitalization technologies on retail supply chains. At one time, it was thought that tablets and smartphones would have only a marginal impact on business processes, but the opposite is now

proven (Fuentes, 2017). Even simple processes such as digitizing labeling can fundamentally change a retailer's pricing strategy, making it more flexible and transparent (Soutjis, Cochoy, & Hagberg, 2017).

In our research, we investigate what digitalization trends are prevailing in retail, how these trends can be framed, and how companies are trying to respond to these trends by implementing different digitalization projects.

Chapter 2 provides an overview of the prevailing trends and conceptual frameworks pertaining to digitalization in the retail industry, as documented in scholarly literature and prominent consulting firms. Additionally, this chapter aims to harmonize the various approaches that have been proposed. Nevertheless, this study also encompasses the increase of customer experience, the mitigation of hazards, and the subsequent amplification of value generation within the domains of tourism and hospitality. Chapter 3 provides a comprehensive account of the research methodology employed in this study. It encompasses the selection process for the retail segments under examination, an analysis of their key characteristics, the methodology applied to picking companies within these segments, and a description of the interview procedure and its associated aspects. In chapter 4, we describe in more detail the selected companies and the digitalization strategy they have followed, illustrating the implementation of these strategies by describing a specific digitalization front-end project. The paper concludes with a summary and a bibliography.

2. Digitalization trends in the retail sector

In this article, we focus on digitalization as a trend affecting the retail sector. In addition, the other trends discussed in the previous chapter are also impacting the sector, but we do not consider them to be the focus of our article, so we will focus on digitalization.

This study explores the many digital trends within the retail industry through two distinct lenses. The first lens encompasses the findings of scientific papers published in both international and domestic academic research journals. The second lens involves the insights derived from research reports produced by prominent consulting firms. Based on these, we would like to show, by comparing relevant sources published in the recent past, that they are fundamentally built around the same concepts and describe for us the direction in which the retail sector is heading in terms of digitalization. The final research framework that will be used to analyze the interviews will be established based on these.

2.1 Literature review

The retail landscape has changed rapidly in recent years, mainly due to the widespread use of technologies that have led to the era of digitalization and Industry 4.0. In order to effectively capitalize on emerging business models, decision-makers must possess a comprehensive understanding of how they can utilize these technologies (Grewal et al., 2017; Pantano & Vannuci, 2019). Furthermore, they have to determine the optimal combination of these technologies to generate a favorable impact on the value chain. Consequently, decision-makers should be equipped to formulate a strategic plan that accommodates the corresponding changes. (Kumar, 2016). A successful example of this shift is Wal-Mart, which has been able to adapt to the digital revolution and develop a new strategy to counter the expansion of e-commerce competitors such as Amazon (Makridakis, 2017; Investopedia, 2019).

The advantage of the emerging new business models lies in the appropriate use and combination of digitalization for commercial companies, whereby technology becomes a competitive advantage in value creation. (Hänninen, Smedlund, & Mitronen, 2017) As a result, many large retail chains are increasingly using digital tools in their processes in their physical stores as well (Hagberg, Jonsson, & Egels-Zandén, 2017), supported by technologies such as artificial intelligence or robotics, thereby becoming more competitive. This means lower employment costs but also lower profits in the short term due to current high costs. For this reason, a more likely way for smaller firms to gain a competitive advantage is to build a personal bond between employees and customers (Shankar, 2018; Bertacchini, Bilotta, & Pantano, 2017)**.**

Any company that plans to move its strategy towards digitalization must meet and invest in certain technological factors. To maximize synergies, companies need to think in terms of both integrated technologies and processes. Agárdi (2018) discusses the integration effects of retail digitalization, stating that "digitalization blurs the boundaries between offline and online channels, retailer and customers roles, and products and services" (Agárdi, 2018, p. 52), i.e., she divided the areas of integration into three main parts: 1) online and offline channels; 2) retailer and customer roles; and 3) products and services. Several of her examples can be observed in the companies we studied, such as Click&Collect, mobile scanners, and some other digital solutions. Our model, which is based on the value chain and will be presented later in the article, is also based on the existence of these integrations; without them, value creation in the classical sense would not be possible.

It is very important that the organization also support technological efforts, and employees should see the positive side of it and not see technology as doing their work for them (Bagdasarov, 2018; Priporas, Stylos, & Fotiadis, 2017). However, in Frey & Osborne's (2017) model, calculating the potential for automation of a total of 702 occupations, they found that in retail, the job of salesperson is most at risk as one of the most automatable jobs. Such an impact of technology will pose major challenges for human resource professionals.

It is not only those working in the field of human resource management who are facing different challenges in their day-to-day work. The technological evolution of retail service delivery also raises new questions about the relationship between retailers and their customers: how do they relate to emerging technologies, and how does this affect their buying processes? The potential impact of human interaction with machines and robots on human behavior is a subject of inquiry (Keeling, 2011). A relevant question arises regarding the extent to which individuals will exhibit a more favorable attitude towards anthropomorphic or humanoid robots. Research by Lu, Cai, & Gursoy (2019) suggests that anthropomorphic appearance negatively influences customers because of the importance of interpersonal relationships.

Marketing professionals also face increasing responsibilities. Only selling a product to customers is insufficient in light of increasing market competition. Consequently, it is crucial to transform customer purchasing into an experience that enhances the probability of recurring purchases. Digital technologies also play an important role in these customer experience enhancements, and several studies have shown a positive relationship between them.

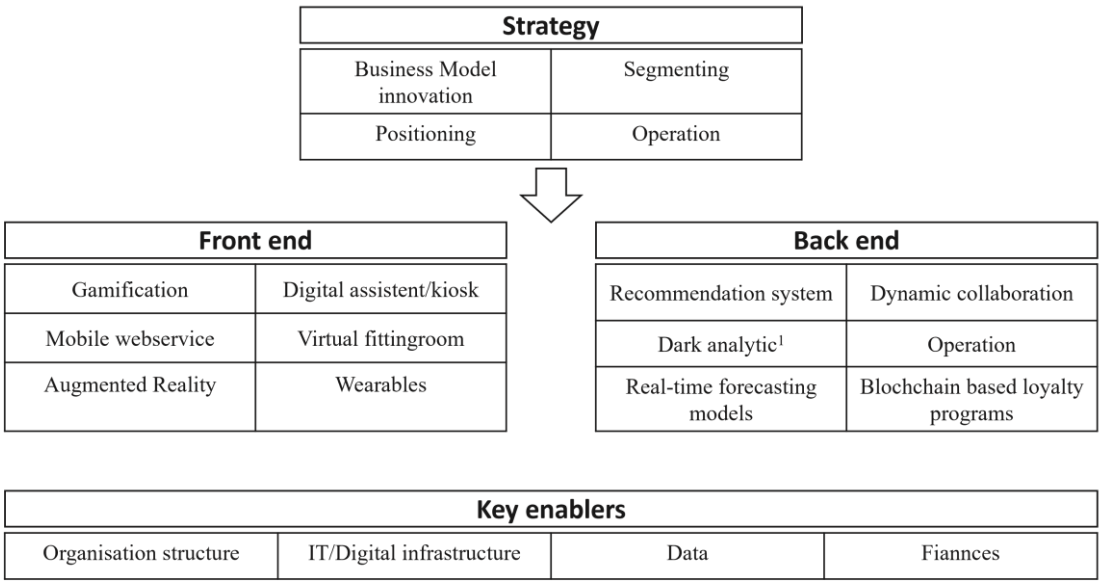
The customer's path to purchase can be divided into five main parts based on Willems, Smolders, Brengman, Luyten, & Schöning (2017). In their article, they show how these main stages can be supported by digitalization tools to encourage customers to make a purchase, with the customer experience playing a key role in it. New technologies allow customers to passively experience products, but this actively contributes to the experience (Lehdonvirta, 2012). Here, we can think of software that allows us to see how a dress would look on us from home and therefore not have to go to a store to try it on. However, there is also a wide availability of in-

store digital tools that can influence customer choice, make the shopping experience easier and more enjoyable, and thus have a major impact on value creation. These tools have a major impact on both promotional and pricing models, while the technological conditions for them also need to be addressed (Grewal, 2017). The potential of omnichannel shopping, i.e., the ability for customers to purchase the product they are looking at, not just online or offline, is also closely linked to the notion of customer experience and value creation. According to Verhoef, Kannan, and Inman (2015), omnichannel management refers to the integration of several channels and customers with the aim of enhancing the customer experience and optimizing channel efficiency.

2.2 Consultancy research reports

According to PwC research reports, Industry 4.0 and the continued spread of digitalization mean that there are a number of new business solutions that retail companies need to consider when faced with this new landscape (PwC, 2016a; PwC, 2016b). In recent years, retail and consumer goods companies have focused primarily on digitizing the customer side, with digital integration of the end-to-end value chain becoming a strategic priority. This includes digitizing products and services, developing innovative digital business models, digitizing and integrating supply chains, and adopting data and analytics as core capabilities. Implementation means more than just developing a new strategy: corporate culture, management approaches, the role of IT, and the drivers of innovation need to be re-examined and often innovated (PwC, 2016a).

The Deloitte (2017) report distinguishes between four important areas: 1) strategy; 2) front-end and back-end, and 4) the factors that are key to the implementation of digitization improvements (see Figure 1).



[1] It is the analysis of data that is available to the company through various data collection processes, but has not been used in decision-making. Data is collected through sensors and telematics tools.

Figure 1: Impact of digitalization on retail chains (Deloitte, 2017, p. 14)

The strategy shows the business model innovation required by digitalization (pricing, location, scale, assortment), the importance of segmentation and positioning to reach customers more effectively and serve their needs better, and the way of operating. Front-end is understood as the processes that the customer encounters directly in the store. This includes the store design itself with its digital assets, communication, promotions, and pricing solutions that affect the customer experience, together with loyalty programs. The back end includes supply chain, logistics and warehousing, digital procurement, vendor management, selection design and planning, human resource management, and financial automation. The last element summarizes the key factors that play a crucial role in the implementation of digital developments. These include the organizational structure, the quality of IT and digital infrastructure, the management and use of data, and the structure of financial processes (Deloitte 2017).

In the context of Írma Agárdi's research on the integrating effect of digitalization, we will not analyze these components individually. Instead, we will focus on the summary statements provided in various consultancy reports. Finally, we will present a comprehensive overview of the different digitalization solutions and their respective impacts on the main points discussed.

PWC has identified twelve areas where new digital technologies will have an impact in the future:

1. Loyalty programs: customers increasingly expect personalized rewards in return for their loyalty;
2. Building a customer base: retailers are turning to technology to help their staff build relationships with customers;
3. Shop space planning: the incorporation of technological advancements is significantly transforming the landscape of retail spaces.
4. Pricing models: in the light of personalized discounts, offline spaces should also open up to dynamic pricing;
5. Value-added services: physical stores have recognized that they have become virtual showrooms for online sales channels and are developing more effective solutions to retain sales;
6. Omnichannel integration: there is a growing need for future customers to increase their engagement and develop inventory management systems;
7. Stock management: sophisticated displays allow customers to access products regardless of size, color, function, and location;
8. Social media: expectations are growing for the use of social media by retailers, where companies need to lead the way, not lag behind;
9. Product mix: retailers can plan the placement of products in the physical store more effectively than ever before;
10. Effective management of staff: the role of staff is changing in businesses, which brings with it the use of new training techniques, rethinking hiring expectations, and the type of compensation;
11. Cashiering: the payment process is changing with the evolution of preferred payment methods and the spread of cash substitutes;

12. Loss prevention, data protection, and cybersecurity: the impact on any particular sales channel has repercussions on all other channels. (PwC, 2016b).

Based on research by Donnelly & Wright (2017), Accenture's findings indicate that the typical customer has access to over one billion products worldwide. The retention of loyal customers is a delicate matter, requiring the fulfillment of essential customer expectations within the contexts of cost, choice, and convenience. Donnelly and Wright (2017) highlight four crucial criteria that retail chain managers must consider in order to remain competitive in the digital era.

1. use digitalization to understand and connect with their customers;
2. start to introduce and use the technologies that have the greatest impact on current industrial processes;
3. need to try new business models; and
4. It is imperative to possess the essential talents required for the forthcoming decade.

Figure 1 shows the technologies that are anticipated to be accessible to decision-makers by the year 2020, with the aim of optimizing the development of customer value. Furthermore, it is anticipated that by the year 2025, three additional technologies, namely 3D printing, blockchain, and self-driving vehicles and drones, will witness a more comprehensive realization of their promise.

Technology	**Production, design, and procurement**	**Distribution, transport, and handling**	**Sales**	**Post-sales activities**
Internet of Things (IoT)	Automatic reordering, smart clothing	Visibility of transport processes	Automated ordering, interconnected devices	-
Artificial intelligence (AI), machine learning	Trend and quality forecasting	Preparation based on forecasting	Forecast-based recommendations and deliveries	After-sales services
Robotics	Production by robots	Robotized picking	Robotized picking, automated sellers	Automated customer support
Digital tracking	Monitoring stock levels and restocking	Monitoring stock levels and restocking	Article tracking and product origin mapping	Product use and warranty

Augmented reality (AR), virtual reality (VR)	Planograms, product designers	-	Virtual retail interfaces, VR presentations	AR/VR engagement

Figure 2: The role of retail technologies in value creation (Donnelly & Wright, 2017, p. 5)

Digitalisation and the new and more advanced technologies that come with it also provide opportunities for new business models. The social economy model has been increasingly successful in the recent times, but experts believe that others are on the way (such as the growing use of personalisation, smart sensor-driven refills or the increasing outsourcing of services). In addition, to realise the potential of digitalisation, a retail company needs to have the following capabilities:

- the ability to think in partnership, because in today's fast-paced world, a company must no longer rely on itself alone;
- last-mile delivery capability for cost-effective, environmentally friendly and responsive solutions to customer preferences; and
- advanced data science skills, because collecting customer data is no longer enough. Data mining for enhanced decision making is no longer just a good option, it is essential for successful business.

The BCG findings were reported by Bhave, Biggs, Burggraaf, Loftus, & Pathak (2018), with four main findings on the state of digitalization in retail chains:

1. IT operating costs in the retail industry account for 1.2% of revenues on average.
2. Retailers ability to innovate with IT depends on investing in e-commerce infrastructure and continuously improving their own omnichannel capabilities.
3. Overall, there is not yet sufficient innovation based on IT developments, and
4. The ability of retail chains to innovate is limited due to their slow adaptation rate and the need to introduce new approaches and developments.

According to Bhave et al. (2018), IT organizations in retail networks need to focus on four key areas if they want to effectively exploit the opportunities in IT development:

- support for personalization: this should help to strengthen the relationship between the trader and the customer. By collecting customer data and using advanced data processing and analytics, companies can understand their customers' consumption patterns, target them, tailor their services to their needs, and prevent competitors from luring them away.
- Omnichannel capabilities (the ability to buy products across multiple channels): today's customers are increasingly moving more easily between physical and online spaces for shopping. They expect that if they buy something online, they can pick it up in-store or return it in-store if they have ordered it online and picked it up in person at home in case

of a problem. Retail chains need to be more adaptable and responsive in how they address these needs.

- investments in e-commerce software and infrastructure: given the growth of online sales in almost all retail segments, it is essential that retailers achieve a strong online presence.
- exploring innovation opportunities and directions: this includes the use of ideas and tactics that commercial companies do not use in their normal business or day-to-day IT activities, such as participating in hackathons, using technology-driven M&A, partnering with venture capitalists, and opening offices in geographic technology hubs (e.g., Berlin or Silicon Valley).

Based on the consultancy research reports examined above, it can be concluded that there is a similar framework for the impact and potential of digitalization on retail (summarized in Figure 3). It is worth noting that the interpretation of certain technologies is confused, and there may be differences between them. Indeed, synergies between technologies blur the conventional interpretation of technologies, and further research is needed to clarify these, which is beyond the scope and purpose of this paper. The broadest and most comprehensive framework has been developed by Deloitte (2017), so we will now group the various findings of the consultancy studies along the four key aspects they identify in order to provide a logical framework for their conclusions and findings and to set the structure of our own model and research framework. Some digitalization solutions have an impact on several aspects; this also shows that the boundaries between the different elements are blurred, bringing them closer together. This is also a proof of their integrating effect. For this reason, it is necessary to introduce a model in the future that can show this process. It is no coincidence that consultancy reports use the Value Chain concept to show the effects of digitalisation, so we would introduce and incorporate this model into the Deloitte study framework, but extended by the other consultancy reports studied, as shown in Figure 3.

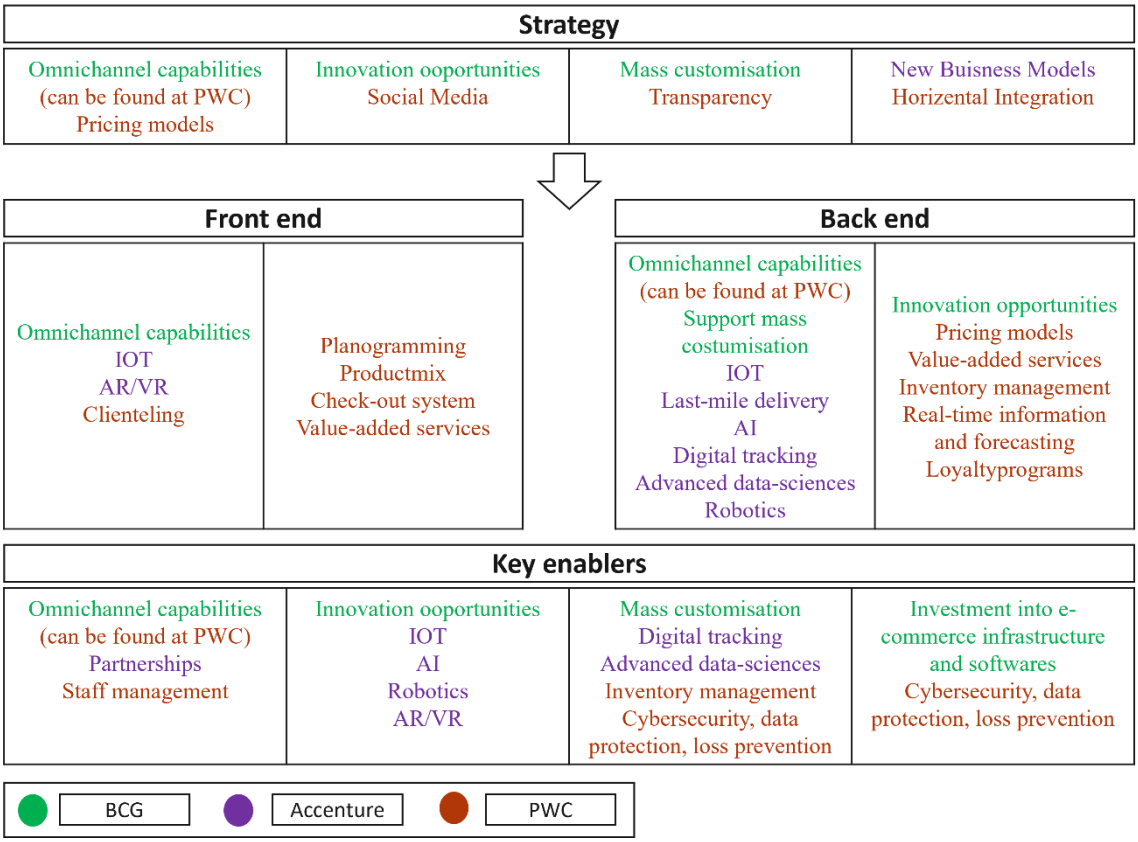


Figure 3: Summary of digitization trends in a coherent framework (own edits based on PwC (2016a), PwC (2016b), Donnelly & Wright (2017), Deloitte (2017) and Bhave et al. (2018))

2.3 Our analytical model

By using existing scholarly literature and consultancy research reports, our aim is to construct a new analytical framework for empirical research, utilizing a pre-established model as its basis. The relationship between digitalization and business value creation activities is extensively discussed in both academic literature and consultancy research reports. As a result, we decided to make use of the Porter value chain model, which Porter created in 1985. Consequently, we conducted an analysis on the impacts of digitalization on supporting activities and core activities individually, as depicted in Figure 4.

From a corporate strategy perspective, the emergence of omnichannel capabilities and new business models is creating a new environment for companies that will fundamentally affect the way they build their value chains. The role of financial investments in IT and e-commerce infrastructure as part of the corporate infrastructure is significant, while for the human resources strategy, the question is how these digitalization solutions will affect the hiring and training processes of retailers. In order to properly design an IT strategy in such an environment, it is necessary to have a technological mindset within the company to ensure that decision-makers have sufficient affinity for these digitalization efforts. A certain level of technological sophistication and the right IT infrastructure in the company are necessary to achieve the right level of digitization efficiency. The supporting role of forecast-based inventory management systems is essential for the procurement process.

In the case of core activities, businesses can be split into back-end and front-end activities, where the sales itself take place. In terms of logistics strategy, digitalization can have a major impact on warehouse and inventory management, as well as on transport processes and store operations. In terms of the front end, the focus will be on marketing strategy functions, where

the key elements here may be to provide a customer experience and educate customers on the use of digitalization tools to ensure that the customer experience is enhanced. Of course, these processes must form an integrated whole to maximize value creation for customers.
The main elements and their technologies shown in Figure 3 are integrated into our model, as, for example, enhancing the customer experience would not be possible without the right combination of AI, VR, AR, and other technologies (front end), which builds on the potential of new business models and serves the emerging needs of personalization (strategy). The lack of advanced data science would make forecast-based procurement and inventory management impossible, and the efficiency of warehouse and inventory management would fall short of current capabilities (back end). The examination of innovation potential and directions would not be feasible without the application of technical thinking.

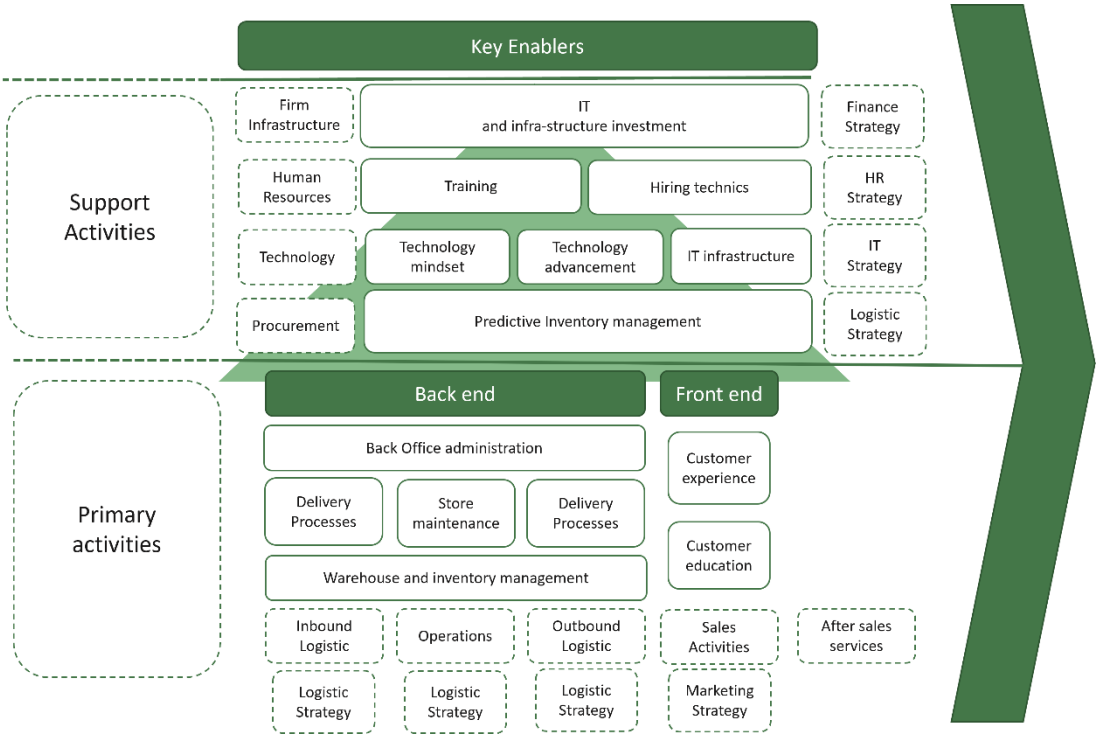


Figure 4: Impact of digitalization in the context of the Porter value chain model (own editing based on Porter 1985)

3. Methodology

The Hungarian retail trade sector can be divided into three major sections according to the KSH database (food, non-food, and fuel). Figure 5 shows the contribution of these sections to the change in the volume of sales at shops.

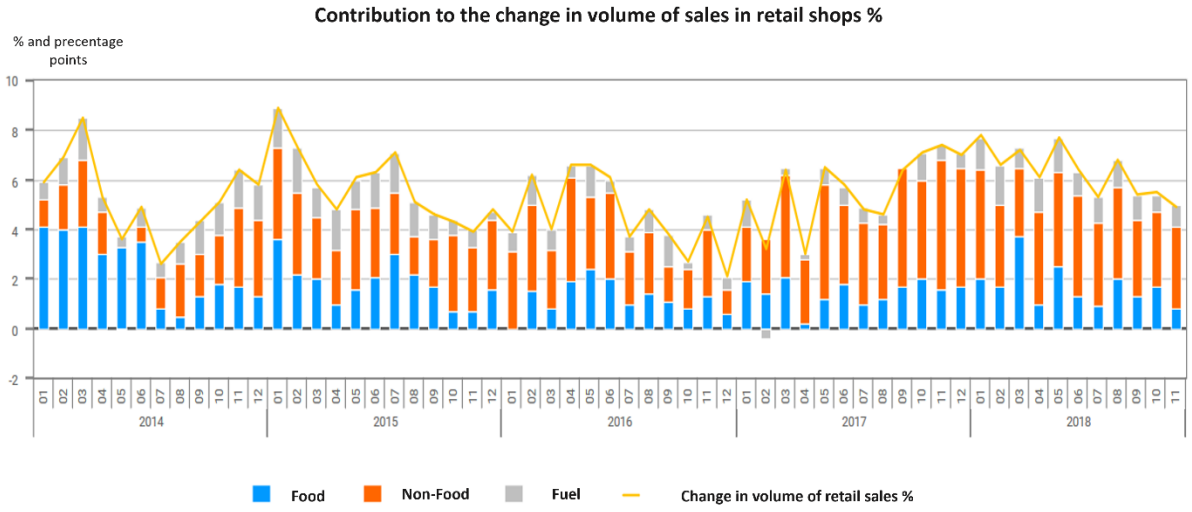


Figure 5: Contribution to the change in volume of sales in retail shops (KSH, 2019a)

The total turnover of retail stores in 2018 was 11,219 billion HUF. Of this, motor vehicle fuel sales accounted for 1 902 billion HUF, food and food-related miscellaneous products for 5 101 billion HUF, and non-food products for the remaining 4 216 billion HUF. However, in addition to the continuous volume growth, the application and integration of digital technologies into business practices still leaves much to be desired, not only in retail but also in the whole economy. Hungary is ranked 25th in the EU in this area (KSH, 2019b). 66% of businesses had a website in 2018 (EU-28 average: 77%), 18% purchased cloud services, and 41% of the Hungarian population made private purchases online (EU-28 average: 60%). An interesting dichotomy is that the share of turnover from e-sales exceeded 1% of net turnover for only 13% of enterprises in 2017 (EU-28 average: 5%), but 23% of total turnover came from e-sales (EU-28 average: 17%) (KSH, 2019b)! Indeed, online shopping is becoming increasingly popular among the Hungarian population. While in 2005 online retail sales amounted to only 19 billion HUF, this increased to 319 billion HUF in 2015 (DKFS, 2017) to reach 625 billion HUF in 2019 (GKI Digital, 2020).

However, retail itself is a rather heterogeneous sector, so, given the limited research resources, the companies we selected should 1) be from the segments that best represent retail chains in Hungary, 2) be significant in terms of both traditional and e-commerce, and 3) have a preferably different market structure. Based on these criteria, the companies we selected for our analysis were selected from the clothing and sports retail segments. Support for the first criterion is provided by Statista (2019a), which shows the largest number of clothing and fashion chains in our country (42 in total), followed by retail chains in the sports and leisure industry (19 in total). Based on the second criterion, the total turnover of textiles, clothing and footwear, and sports, hobbies, and toys products was about 860 billion HUF in 2018 (about 20% of the non-food products segment) (KSH, 2019c; KSH, 2019d). On the e-commerce side, by type of product ordered, the highest proportion of shoppers (17%) ordered clothing and sports equipment online (KSH, 2019b). And, as the third aspect shows in the segment descriptions below, these two segments also have different structures, so they meet our expectations.

Brief overview of the selected retail segments

Our first company (fast fashion) belongs to the textile, clothing, and footwear segment, with a total turnover of 690 billion HUF in 2018 (KSH, 2019 c). According to Bucsky (2019), clothing

retailers accounted for just over half of the total turnover in textiles and clothing (slightly above 300 billion HUF), and their aggregate profit has been around zero for years (total loss of 9 billion HUF between 2013 and 2017, with a total income of 1 411 billion HUF). There is also a trend towards concentration in the Hungarian market. Although the total turnover of clothing retailers is steadily increasing, the number of companies and clothing shops is decreasing, while the number of employees remains stable. As a result, the market share of the top 20 firms in terms of turnover approached 55% in 2017, and this trend is expected to continue in the near future. Among these companies, H&M, C&A, and Zara stand out, together accounting for around 25% of the market turnover. The dominance of companies with a foreign background and fast fashion chains is generally characteristic. Only four of the top 25 companies in terms of turnover are Hungarian, accounting for 11% of the turnover of these companies continuously over the last five years. More than half of the companies with the highest turnover are active in the fast fashion segment (including the three largest mentioned above), and only one is active in the luxury market. It is also the largest firm that is able to generate sustained, significant profits in its home market.

Our second company under review (a sports equipment retailer) is a distributor of sports, hobby, and toy products, with a combined turnover of around 170 billion HUF in 2018. The segment has grown by 10% in each of the last two years. There is strong seasonality in sales, with the fourth quarter generating roughly one and a half to two times the turnover of the first quarter, while the second and third quarters have roughly similar turnover, falling between the first and last quarters. (KSH, 2019d; KSH, 2019e). Decathlon is the clear market leader in this segment, with sales of 61 billion HUF in 2018, covering roughly 35% of the market and growing dynamically by 14% compared to 2017. Hervis (10.93 billion HUF) and Adidas (10.5 billion HUF) followed strongly behind, essentially stagnating compared to 2017. Further rapid growth in e-commerce revenues is expected in the near future, with the rate of expansion set to exceed the growth rate of the sector as a whole, practically doubling to 25 billion HUF by 2023, compared to 13.7 billion HUF in 2017 (Statista, 2019b).

Selection of companies and data collection process

Our research was carried out in the framework of the EFOP-3.6.2-16-2017-00007 project "Aspects of the development of a smart, sustainable, and inclusive society: social, technological, and innovation networks in employment and the digital economy", which aimed to investigate the meaning, content, and implementation of Industry 4.0 in the business environment through case studies. In the context of our study in the retail industry, we have examined the implementation of Industry 4.0 by focusing on the process of digitalization. We have used information from a wide range of sources. Secondary sources of information included industry analyses, articles, studies, publicly available statistics, company websites, and financial reports. These were used to identify the characteristics and players in each segment, as described above. The selected companies are among the major players in the domestic market in both segments and are Hungarian subsidiaries of international multinational chains, so they have a good insight into international trends and can place domestic market developments in them. A series of semi-structured interviews were carried out with a total of 11 over the latter part of 2018. Among these, six interviews were conducted at fast fashion companies: one with the Hungarian country manager, two with the HR manager, one with the general area manager, one with the area manager of one of the company's brands, and one with a former assistant manager of the company. Five interviews were conducted at the sports retailer: one with the customer experience manager, one with each department manager and a digital ambassador of the company's digital test store, and two more interviews with two employees of this store. The

structure of the interviews was based on the data collection guide used in the project. On this basis, the interviews covered a number of relevant areas, such as international and domestic industry trends and players, digitalization practices, the parent company and the home company, the link between corporate strategy and digitalization, the financial resources available for digitalization, the involvement of employees in digitalization projects, and in-house digitalization projects.

Analysis

Presentation of the companies

The fast fashion company is the Hungarian subsidiary of a major international chain. The parent company, which has a history going back several decades, has several brands with separate design, sales, and management structures, all of which are brought together by central management. Some of the brands already have online retail solutions, which will be extended to all brands in the near future. The process of international expansion occurred during the latter years of the 20th century, leading to the establishment of a significant presence in numerous countries. This international presence covers an extensive number of stores, the majority of which are owned by the company, while a smaller portion operates via franchise agreements. The group has several regional purchasing centers, while distribution is centralized on the mainland, supplying all stores, whether owned or franchised. The group is present in Hungary with several, but not all, of its brands. Despite the fact that the various brands' legal owners are different businesses, the country manager is in charge of managing them as a single entity. In line with the practice of fast fashion companies in Hungary, the brands' stores are located in locations where potential customers are most likely to make a purchase in shopping centers. The Hungarian subsidiary is widely recognized as an important player in the Hungarian fast fashion industry, with its primary focus being on apparel retailing. The number of employees exceeds 100.

The parent company of the sportswear retailer is a European-based global company that designs and sells sports-related products and apparel in more than 50 countries. The company's mission is to bring the power of sport to everyone, everywhere, in a sustainable way. Key values are innovation, high quality at low cost, efficiency, building lifelong relationships with customers, reducing environmental impact, and valuing employees. It offers its products and services to customers through more than two dozen brands. The company is building a network of company-owned stores and selling its products through them and online. The stores typically possess expansive floor surfaces and are located in suburban areas within shopping centers. An increasing number of retail establishments are emerging within urban centers, characterized by reduced physical dimensions yet strategically positioned in central areas. The Group is present in Hungary with its full range of products and is a major player in the sports equipment retail sector.

In both companies, the emphasis on digitalization initiatives has primarily centered on enhancing operational efficiencies in the back-end. However, there is a growing prominence of efforts aimed at improving customer-related aspects on the front end. In the following, we describe the perception and organizational embeddedness of the digitalization strategy, the process and types of digitalization improvements for both companies, and then discuss a front-end digitalization project in detail.

Digitalization at fast fashion company

1. Strategy and organizational embeddedness

Digitalization is seen as an important driver for the company group, but the organizational culture does not necessarily support the rapid uptake of these solutions. The company has very strong centralized management of everything. Digitalization developments in the company are implemented as a combination of in-house and outsourced developments, with different proportions per project. The Hungarian subsidiary can take advantage of central development. The development of digitalization solutions is primarily a question of money; the necessary know-how is available, and it is up to the head office to decide where to allocate the resources needed for investment.

2. Process and types of digitalization developments

The development process focuses on the home market, where all innovations undergo testing before being gradually distributed to the international level in multiple phases throughout the implementation process. Cross-development between brands is possible but requires top-level approval. The management is done through country managers, but decision-making is fully centralized, with subsidiaries (including the Hungarian one) essentially limited to suggestion-making. Their own development can be minimal, but some level of adaptation is possible due to cultural differences between countries. Frequently, the imposition of the mother country's policy is felt, and local concerns must be defended. Information on development projects is usually only received from the center at the implementation stage, and it is not always possible to know why a potential project is not going ahead. An example of this is the introduction of a chip card gift voucher in Hungary, for which all the technical conditions are in place and it would have been a quality development, but for some reason it has been killed off, and there is no clear information about the reason for this.

Digitalization solutions are still essentially about making internal processes more efficient. Customer-side solutions are not spreading as fast in the industry, but initiatives are already emerging. Despite the rapid growth of the online segment, the country manager of the company surveyed maintains the belief that physical consumption continues to hold significance. A typical European customer, probably also because of the shorter distances compared to the US, needs more time to make the switch, e.g., to reach at least 4 shopping centers within 20 km. Also in Hungary, with shopping center retailing concentrated in Budapest, it will be difficult to adapt to US trends. Most clothing brands have a similar view; e.g., Inditex and LPP Group are opening physical stores across Europe. Although the country manager interviewed also orders more online, it is because of time constraints, and she knows what she is ordering. She holds the belief that physical retail establishments continue to possess a valid reason for existence, as the act of shopping serves as a means of enjoyment rather than solely an opportunity for purchasing goods and additionally represents a lifestyle choice for younger generations.

3. Digitalization front-end project: the Tablet Online Ordering

The digital revolution cannot be avoided, and online presence is becoming increasingly important for fast fashion brands. The company has an online presence, but it does not have a well-developed framework, and there are questions about the development projects related to it. One of these, the Tablet Online Ordering (TOO) project, is presented in more detail. The essence of TOO can be summarized as follows: A tablet is placed in the store, which the customer can use to access the brand's website and order products from it. Beyond this basic functionality, the TOO could be extended with a number of additional features (at the discretion of the head office), e.g., to measure customer satisfaction, which could be used to replace trial purchases, as it makes a difference whether the store receives one trial purchase per month and the salary of the employees depends on it, or whether there are at least 50-100 or more feedbacks

from customers while they are waiting at the cash register. In addition, the customer could check the stock in another shop, which would replace the current solution where the shop assistant can only check this stock position on the cash register machine but cannot cash out in the meantime. The product ordered through TOO would be sent from the central online warehouse on the mainland and would be sent to the customer together with the normal delivery from the shops, but labeled in a separate box.

TOO, like other developments, was first tested in the home country and then scaled down to an international level. The second stage was in France and Belgium in September 2018 and will be rolled out to Hungary and Serbia in 2019. In the end, the French market was not retained for development, but this was not for technological reasons but for financial ones. Indeed, the current central concept is that the future revenue of TOO will not be added to the revenue of the shop but will go to a separate online cashier. This practice is contradictory to the interests of individual countries, as it diverts the time and effort of retail employees away from their primary responsibilities. Moreover, the benefits derived from this system are not granted to the workers themselves. Consequently, it is unlikely that national governments would have an interest in endorsing its implementation. Instead, sellers would prioritize customer acquisition in order to increase their earnings through commissions. This problem would currently be addressed by giving the employee who generates sales through the TOO a share of the revenue, but the country manager says that the way this would be handled is completely unclear and would be difficult to implement. The quantitative impact of the TOO on firm performance remains uncertain and requires further investigation to determine its efficacy. In Hungary, there is seen promise for this initiative, as the necessary wifi infrastructure is there, although it lacks the essential tablet devices. This would be sent centrally to the shops, pre-configured to connect to the wifi network immediately. It would not be a large investment, as one tablet per store would be needed at 30–40 thousand HUF per tablet, but even this would probably be discounted by the operators, as the center would order them in bulk on a global scale. Looking at Hungarian competitors, this would be an extra service, and in the current competitive environment, any such small advantage could be important.

Combining the above into the model we have sketched, we can see the following for the fast fashion company under study (Figure 6):

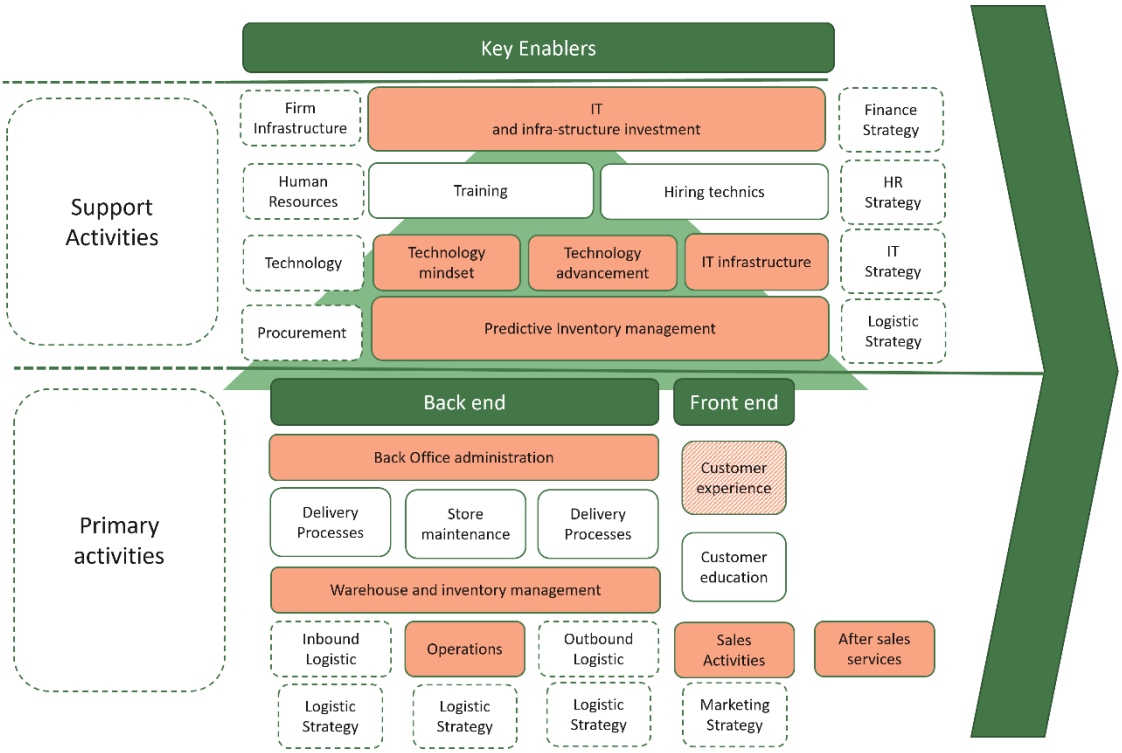


Figure 6: Digitalization solutions used in the value chain model of fast fashion (own editing adapted from Porter 1985)

In terms of support activities, digitalization is an important aspect of most strategic areas of fast fashion companies. The company has a highly developed IT infrastructure and the mindset to exploit it effectively, although the focus is more on back-end activities. Dedicated financial resources are devoted towards digitalization initiatives, mostly emphasizing centralized management. Subsidiaries, on the other hand, possess limited means of contribution, typically limited to a suggestion box facilitated by country managers. This strict hierarchical approach may limit the direction of future developments, although there are increasing efforts to shift the focus from the back end to the front end. This is partly due to the fact that effective support for the digitization of back-end administration is already in place, including the management of inventories through the company-wide implementation of a real-time system. On the one hand, the marginal benefit of further back-end development is therefore decreasing, while on the customer side, there is a growing demand for advanced digitization solutions. However, the fragmented industry structure itself is somewhat limiting the opportunities, as most companies are carefully selecting their options for development and taking into account the longer expected payback period due to lower profit margins resulting from fierce competition. These are also reasons why there is still a lot of potential for front-end developments in the industry.

As mentioned above, the clear focus in terms of core activities has been on the back end, but there is now a noticeable shift towards the front end. In addition to TOO, other customer projects are planned, but for the time being, the extent to which digitization has improved the customer experience is limited. As front-end digitization increases, customer education is expected to come to the fore, but at this stage it is not actively addressed, nor is the recruitment and training of salespeople focusing on digitization skills but rather on improving the ability to deliver offline business. The increased rate of staff turnover within this particular sector contributes to this phenomenon.

Digitalization at the sports retailer

1. Strategy and organizational embeddedness

The company's central management is fully committed to digitalization and is working to ensure that it has the organizational support to do so. Educating customers, ensuring customer experience, and increasing customer satisfaction are important pillars of the corporate digitalization strategy. The company is currently in a very serious education phase. They are open about this role and would like to take on the need to educate their team on the use of these digital tools and methods, but they have a much bigger task with the market. It is precisely thanks to one of these digital innovations, for example, that the customers in the company's downtown store are not as young as they thought but are mostly between 36 and 60 years old. They are the company's most affluent base because they are the ones who can most afford to live downtown. Because of this age group, their customers are less digital and less likely to shop online. They are not ready for these changes, so there is a need to educate customers as well as employees.

Costumers are not interested in whether they encounter online or offline channels. From his point of view, he is connected to the company and expects the same level of service, value for money, product quality, and benefits regardless of which sector of the company he is dealing with. There is a part of digitalization that has to be perfect, and that is the user experience. To ensure this, the company is constantly collecting feedback from its customers, with between 4 000 and 9 000 reviews coming in every month, depending on the season. All reviews are text-based, describing what they experienced, what they were satisfied with, and what they were not. This provides the company with a huge store of knowledge from customers, and it tries to address this as much as possible. Finally, in addition to the reviews and the user experience, they have also launched a movement to help build communities because they really want to set an example. In the digital world, people's loyalty to companies is much more volatile, so one of the biggest challenges is to continually strengthen and maintain that.

The company uses both internal and external partners for digitalization projects. The organizational structure is more complex but supportive of developments. Three important actors within the group are worth mentioning:

- Central R&D department (known internally as "Labs"): they are responsible for development and are linked to the so-called national digital ambassador (more on this role below).
- Parent company: only senior management and the head of test shops communicate directly with them.
- In-house IT team: responsible for internal development at shop level.

There are also partners outside the group, such as the partner responsible for processing customer reviews. The company also works with other external development companies. The tools needed for digitalization projects are also not produced by the company but are sourced from external suppliers. Because of the company's global presence, they can actually find and reach the right partners anywhere. In this case, the Hungarian subsidiary can also take advantage of central developments. In this context, the development of digitalization solutions is primarily dependent on financial resources. The necessary expertise is easily accessible, whether through internal or external networks. Consequently, the allocation of investment resources rests with the central administration.

2. <u>The process and types of digitalization developments</u>

Digital development can take several forms. The company first looks at what they need. If someone in the company has an idea that they could easily implement in the store because they have the tools, software, or just need a simple operation (e.g., something needs to be moved somewhere or set up differently), they discuss it with their supervisor, the store manager. If the idea works, they start documenting it and informing other colleagues through the appropriate interfaces. The company is open to bottom-up solutions; it just needs to find the people with the ideas. This is where digital ambassadors emerge as important players in the digitalization process. Every store has a digital ambassador, so employees know who to go to if they have an idea for improvement. They can discuss it with them, brainstorm together, and contact the right people. The ideal digital ambassador should possess a natural inclination towards digital platforms, a willingness to embrace innovation, and creative thinking abilities. Additionally, they should be capable of promptly accommodating any new developments or initiatives that department managers may wish to express to the store. There is also a national digital ambassador, which includes all store-level digital ambassadors. One of his tasks is to communicate with the central Labs development team, and all the innovations are brought to the stores through him. To improve the flow of information and ideas within the store, the store-level Digital Ambassadors are supported by a departmental staff member called a Digital Ambassador, who actively holds one major meeting per month. Primarily, the digital ambassadors communicate to the salespeople that there is an improvement or news, what it is for, and how to use it. From the employees, they collect information on whether they think this development is a good one. What should be changed to make it work better? Is it useful at all? Do you use it in your work? What is missing? What do you need, and what do you not use? This way, communication goes both ways, so that you always get the best use out of the development.

There are also centrally initiated ideas. These are coordinated by labs and distributed to test shops. In addition to Hungary, there are also test shops in France and Spain. All the developments are tested in the test shops, as they may not work the same in Hungary as in France or vice versa. If the test shops give feedback that the development is OK, it becomes a product and is registered. From then on, any shop in the world will be able to get it through their own ordering platform. Of course, there may be other needs at the local level to which they will have to respond.

A dedicated group of stakeholders decides jointly on the implementation of developments. They meet every month or two, where a project can be validated and a decision taken. However, the store manager typically decides whether or not to introduce a project in a particular store as well as who else in the store will be involved in the decision.

While the digitalization developments are progressing at a fast pace, the company is not yet at the stage where everything is synchronized. This will be the next step to ensure synergies from digitalization solutions. It was a serious realization and decision by the company in early 2018 to set up a team to manage digital projects, headed by a digital project manager who will also operationally lead these projects and work in this area. There is a basic rule of thumb when it comes to digital development: only implement developments nationwide that are 1) simple, understandable, have the given value for customers, 2) are loved by employees and therefore do their jobs more efficiently, and 3) have a financial return.

At both the international and national levels, the aforementioned user-centered approach is the basis for development. The user is at the center of the ecosystem, deciding who to connect with and hoping to be somehow integrated into the life of the company. Because of ecosystems and networking, it is inconceivable that digital solutions and developments are left out. As a result, the focus of digitization efforts is constantly shifting from back-end projects to improve

operational process efficiency to front-end customer-facing improvements, many of which are under implementation.

3. Digitalization front-end project: smart fitting rooms

Within the company's digitalization projects, we now present the intelligent fitting rooms, which are currently implemented in two stores in Hungary, beside the test store. With these devices, if the customer finds a product unsuitable during the trial, he can request it in another size or a completely new product via the display, directly to the fitting room. The system shows only the products in stock and offers only those that are available in the store. It may be that another customer has the product or that the stock record is wrong, but overall, these are the cases where they cannot fulfill the customer's request. Customers really like it because they don't have to go out and get dressed, and they can ask for sizes. In this case, the salesperson gets a notification on their tablet or smartphone and can see which fitting room has which product, which size to take, or maybe they need advice from that particular customer. This request for advice was at first strange for customers; at most, they printed it by accident, but now they really believe they can ask for advice. A new system has been developed to manage it, with trial case managers on a daily basis who manage it in trios on an ongoing basis. All in all, this is one of the most successful and accepted digitization projects from the customers point of view, saving them time and giving them a unique customer experience. There are plans to roll it out to other stores.

Of course, the project has not been without minor disruptions, and there are still areas for improvement. At the beginning of the project, the problematic displays caused a bit of a problem for the department managers and sales staff. Initially, the screens were not touchscreen displays but had lasers in the side and were shot where the customers touched them. These had to be cleaned with compressed air, which was a job for the morning duty staff. They had to be cleaned frequently, and in the mornings they had to check all the displays to see if they were working and if they could be used to call a salesman. This was about 10 minutes, which in itself doesn't seem like a huge amount of time, but considering 365 days a year, it is not an efficient or productive amount of time. With the new displays, however, this problem has been solved. Another problem was that, for a period of time, the tablets would not notify the vendors. This was finally solved by a Hungarian employee, who then communicated to the French headquarters, if it didn't work in other countries, what to do about it. The reduction in the expected daily return from customers has not been shortened yet. Also, on the customer side, people still need to be educated to start using it or dare to use it more. This method does not work for everyone, and some people see it as an intrusion into their personal space when a salesperson brings a product into the fitting room. Pictograms are also used to communicate to customers at the point of sale what the device can do, but the language cannot be selected in the fitting room, so foreign customers have problems using them, and 30–40% of calls are cold calls (children playing with it, accidental presses during dressing, etc.). A further difficulty is that traditional stores are quite reluctant to use smart fitting rooms because they have very high expectations of the quality of service. It should not be the case that the seller does not deliver the requested product within the promised time, as this would seriously degrade the user experience.

The investment cost of the project was in the range of 5 million HUF. The monthly operating costs are around 100 000 HUF, and the project has had a clear positive impact on costs, quality, speed and reliability of service, and labor productivity.

To summarize, the model we have outlined allows us to conclude the following for the sports retailer (Figure 7):

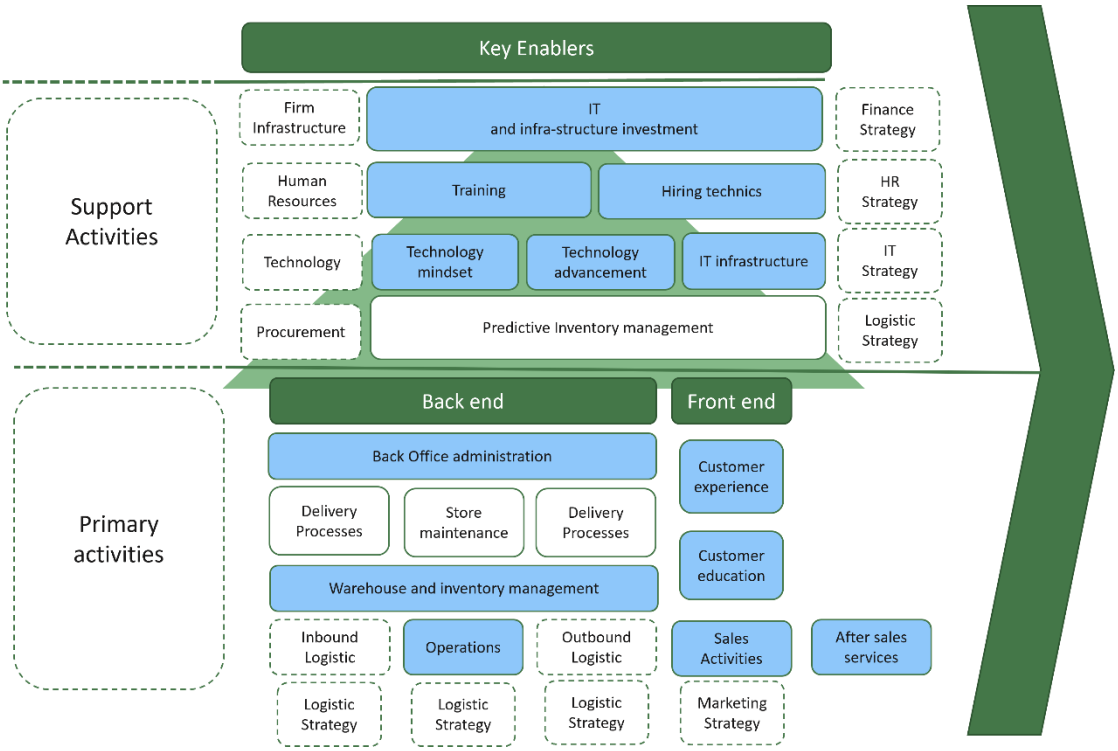


Figure 7: Digitalization solutions used in the value chain model of a sports retailer (own editing adapted from Porter 1985)

Based on the interviews, it can be concluded that digitalization is an important aspect of almost all major strategic areas of the sports retailer's support activities. The organization has a designated budget for investments in IT and technology. A crucial component of their recruitment procedure involves evaluating individuals' digital competencies, supplemented by targeted training sessions aimed at enhancing employees' proficiency in utilizing novel tools. From the perspective of IT strategy, the presence of dedicated ambassadors indicates a particular mindset and a commitment to ongoing improvement. This includes the establishment and maintenance of organizational conditions that facilitate the continuous improvement of infrastructure and technical advancements. Digitalization developments are further boosted by a supportive organizational structure, which, in addition to centralized developments, also allows room for individual initiatives. The Hungarian subsidiary's dominant position in the market is beneficial in this regard, as it enables it to make independent developments by utilizing its own financial accomplishments.

In terms of the main activities, the clear focus is on the front end. This is where various digital tools are used to enhance the customer experience. Examples of such tools are smart fitting rooms. Customer education is also important to them, so front-line staff have a key role to play in helping customers navigate their way around digital tools. Digital solutions are also available for back-end activities, such as shelf scanners to facilitate inventory, customer counters, and software for heat-map store analytics. In addition, contextual analytics software is also used to support the processing of customer feedback throughout the sales process, providing the company with additional valuable information.

Summary

In this article, we looked at the digitalization trends in retail, how these trends can be framed, and how companies are trying to respond to these trends by implementing different digitalization projects. To identify the digitalization trends, we have reviewed and contextualized academic literature and research reports from leading consultancy companies. Within the retail sector, we examined one major company from each of the two main segments in Hungary, namely textiles, clothing and footwear (including fast fashion), sports, hobbies, and toys. In both cases, digitalization is an important part of the companies' strategies, and they have the key factors in place to achieve this. Digitalization has been driven initially by process efficiency improvements on the back-end, but front-end improvements are becoming increasingly important. There are still significant differences in the extent of this across the companies surveyed, influenced by a number of factors. These include the centralized or decentralized nature of the organizational culture and the support for autonomous development, but also the market conditions themselves, which have an impact on the companies' strategies. While a sports retailer is a dominant player in a more concentrated market, a fast fashion company competes in a highly fragmented market where even the market leaders do not have a significant share on their own. This also implies differences in the revenue that can be realized in the market and a need to rethink the pace of development. Nevertheless, the digitization projects presented indicate that these developments will become increasingly important in the future to position themselves in the market. Based on the research model outlined, business leaders need to think about the role and impact of IT in a much broader context than they have done so far. They need to recognize that competition cannot be circumvented by allocating adequate financial resources to such purposes, but to ensure that these are used appropriately and to their maximum effect, this thinking needs to be adopted throughout the firm. It is recommended that a dedicated manager be appointed to this role who has the vision, coordination, and competencies to ensure that the digitalization solution is properly exploited at all levels of the corporate value chain and its impact is felt across all relevant corporate functions, maximizing value creation.

As a further line of research, it would be important to examine the impact of several major technologies on retail value chains individually and thus conduct deeper industry research to determine what stage of implementation these technologies are currently at, to what extent they have already had an impact, and on which element of the value chain. In their 2017 article, Roger Strange and Antonella Zucchella highlight four major technologies impacting global value chains in the era of Industry 4.0. Big data and analytics, the Internet of Things, additive manufacturing, and robotics Against this background, it is worth first looking in more detail at the impact of these technologies on retail chains.

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Annex 3: Dynamic acceleration: service robots in retail

Introduction

The most difficult phase of the COVID-19 pandemic is hopefully behind us, and just when the time for economic recovery was about to come, a new threat emerged in the form of the Russia-Ukraine conflict. Both are threats to the global economy and are pushing economies toward crisis. Amid such global events, a sharp decline was forecasted for 2023 by the United Nations (2023) and although economic activity has slowed at a lighter pace, a turn for the better is far off. Supply chain disruptions, and labour market uncertainties still challenge companies to stay competitive in today's business environment. As a global sector, the current situation of retail is also heavily hit by volatile energy costs, contracting market demand as consumers are spending less and wages are also rising due to inflation.

In this uncertain context, it is important to look at several options that can help companies sustain their competitive advantage, the key to which can be automation and digitalization. Digital development in Europe has been undoubtedly boosted by the pandemic. A publication by the European Investment Bank (2021), among others, draws several important conclusions to build on. The report highlights that digital infrastructure is a major barrier to investment. Businesses that have made efforts to digitalize their operations have managed to adopt better governance practices and are generally more productive; therefore, they are more likely to export their goods and services. Also, those companies that had already been using digital technologies prior to the pandemic are likely to have increased their digitalization activities in response to the COVID-19 crisis. To successfully integrate digital solutions into their processes, businesses need to adopt digital transformation strategies. After the pandemic, several retail businesses saw their traditional business models collapse, and as consumers rapidly had to adapt to digital solutions, businesses also executed digital transformation to fit into this new environment (Gouveia, F. D., & São Mamede, H., 2022).

In the digital transformation process, digital technologies give organizations the impetus to gain or sustain a competitive advantage in conducting strategic actions. For these actions, the question is how companies will react to the various disruptive events and how they will adapt their business models accordingly. To understand this, we looked at the theory of dynamic capabilities, as the mechanisms linking digital transformation to strategic renewal can be explored through this aspect (Vial, 2019). In this article, we examine the impact of dynamic capabilities in the context of digital transformation using a specific technology, service robots, in retail. We chose service robots because of their ability to integrate multiple technologies (e.g., the Internet of Things (IoT) and artificial intelligence). Thus, it gives us a comprehensive picture of the dynamic capabilities required for successful implementation of advanced technologies and a more comprehensive starting point for further research. Moreover, several studies suggest that dynamic capabilities are key to building on when facing turbulent market conditions. Not only is the possession of dynamic capabilities important to ensure local embeddedness for retailers (Cao, 2011), businesses will only be able to survive the hardships

they have experienced if they master these capabilities (Rashid & Ratten, 2021). Dynamic capabilities are also able to steer innovation projects towards feasible outcomes and, by doing so, greatly improve the market success of companies (Chatterje et al., 2023). Consequently, it is clear that dynamic capabilities strengthen the ability of a business to experiment, which is inevitable in times of crisis (Clampit et al., 2021). If all key elements of dynamic capabilities are perfectly combined, companies may achieve a faster pace of value creation, even in turbulent market conditions (Handoko & Tjaturpriono, 2023).

Our research motivation stems from the observation that digital dynamic capabilities are rich in literature, but this literature has not yet focused on retail robotics, although retailers have already adopted the technology in both back-end and front-end processes.

To summarize, our research examines the importance of service robots in retail operations and places a strong emphasis on the role of dynamic capabilities. Robotic technology has gained significant momentum in retail this decade, but little literature coverage was found in the context of digital dynamic capabilities. Our research proposition is that investing in dynamic capabilities will have an overall positive impact on the implementation of robotic technologies, which will sustain the digital competitiveness of retail companies, and we formulate the following research question: Which types of dynamic capabilities influence the application of service robots in retail, and how can these capabilities contribute towards sustaining competitive advantage in the sector? By using two different models of digital dynamic capabilities, a thorough understanding of this phenomenon will be achieved, and the research question can be answered.

In Section 1, we present the impact of dynamic capabilities on digital transformation and then the role of digital capabilities in shaping retail omnichannel strategies. Sections 2 and 3 review the literature, with Section 2 defining robots and Section 3 examining their different applications in a retail setting. Section 4 introduces our methodology. We have chosen a mixed approach consisting of a full document analysis of three news portals. We included a validation process as well, consisting of articles from the literature review of this paper and other articles selected from the ScienceDirect database after a thorough search. Section 5 interprets robots in retail within the dynamic capabilities framework. Finally, Section 6 discusses validity and research limitations.

1 Dynamic capabilities and digital transformation

According to O'Reilley & Tushman (2008), dynamic capabilities are defined as the capabilities of a company to reconfigure assets and existing capabilities to ensure a long-term competitive advantage. Teece (2007) defined dynamic capabilities as the ability to (a) sense opportunities and threats, (b) seize opportunities, and (c) maintain competitiveness by improving, combining, protecting, and, when necessary, reconfiguring the tangible and intangible assets of the business.

In Teece's (2018) simplified model, the relationship between dynamic capabilities, strategy, and business models can be observed. (Figure 1)

INSERT FIGURE 1 HERE

According to the interpretation of the model, the sensing phase involves the identification of opportunities, which are influenced by technological opportunities and can induce technological development processes within the company. The seize phase is where the business model is designed, refined and the resources are allocated. It is the phase most heavily influenced by the company's strategy, through the expected reactions of competitors and the protection of the intellectual property created. These affect the company's business model, in which the strength of its dynamic capabilities plays a key role. The management of a company with strong dynamic capabilities has more freedom to apply business models that involve radical changes in resources or activities. In many cases, corporate strategy dictates the design of the business model. However, the emergence of a new technology that affects most business processes opens up opportunities for radically new business models to which corporate strategy must respond. Based on these, a reconfiguration takes place, where both the structure and culture are refined. It is influenced by the refinement of existing capabilities, and through this, companies invest in acquiring additional capabilities (Teece, 2018).

Dynamic capabilities have an integrational aspect, as they are able to integrate products, resources, capabilities, and business models. For us here, their ability to integrate technologies provided by different parties is key, which enables companies to build successful digital ecosystems and platforms (Vial 2019, Helfat & Raubitschek 2018) that can become sources of sustainable competitive advantage. The development of information technology has implications for other types of multilateral platforms for innovation and change as well, including traditional platforms such as shopping malls (Helfat & Raubitschek 2018).

Studying dynamic capabilities is particularly important in digital transformation research. Based on Teece's (2018) model, Warner & Wäger (2019) have created a process model for the development of dynamic capabilities for digital transformation (Figure 2). In their article, they investigated how incumbent firms in traditional industries build dynamic capabilities for digital transformation. According to the model, digital sensing, digital seizing, and digital transforming can have external and internal inducers, as well as internal barriers and internal enablers.

INSERT FIGURE 2 HERE

Teece's (2018) model focuses on sensing, seizing, and transforming, but when discussing dynamic capabilities, it must be highlighted that change is induced by external factors. In Warner & Wägner's (2019) model, the external triggers of digital transformation are the starting point. These external triggers include disruptive digital competitors, changing consumer behavior, and disruptive digital technologies (such as robots), and they influence the company’s

market position and force it to react in order to sustain its competitive advantage. The first step is digital sensing. It includes the development of a digital mindset and the exploration and design of digital opportunities. Sensing is followed by the step of digital seizing. Rapid prototyping, creating digital portfolios, and strategic agility fall under this phase. Digital transformation is defined by navigating innovation ecosystems, reconfiguring internal structures, and developing digital maturity. These three stages, which define digital dynamic capabilities, are affected by both internal enablers and internal barriers. Enablers include cross-functional teams, rapid decision-making, and managerial support, while barriers include rigid strategic planning, resistance to change, and hierarchy. This process affects strategic renewal in three different areas: the business model, the collaborative approach (among internal and external actors as well), and the culture.

Dynamic capabilities are key to the success of digital transformation. Teece's (2018) model examines dynamic capabilities in a general context, while Warner & Wägner's (2019) model discusses them from the perspective of digital transformation. The latter authors' model points out that dynamic capabilities should not be assessed in isolation but in the context of the three different organizational levels influenced by digital environmental factors and digital dynamic capabilities.

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1.1 Dynamic capabilities in creating retail omnichannel strategies

Mrutzek-Hartmann et al. (2022) have built a generic retail model that encompasses the resources and capabilities needed to develop a successful omnichannel strategy (Figure 3).

INSERT FIGURE 3 HERE

The framework shows which retail processes (back-end, front-end, or both) are affected by a given resource or capability. It describes six resource categories and six additional categories for dynamic capabilities, alongside two categories for ordinary capabilities. Standard capabilities include implementation, which is related to omnichannel processes and availability, including both consumer choice and logistics. Dynamic capabilities are responsible for identifying and matching key trends and development areas for the business. This means that both categories belong to both the back-end and front-end processes and are generally responsible for the proper running of the business. The back-end side of dynamic capabilities also includes innovation related to supply chain management and strategy, the creation of an omnichannel environment and the provision of the associated back-end infrastructure.

Customer interaction processes are related to the front-end activity. We can discuss integrating a new technology into these processes or the development of a customer relationship management system Closely linked to this is the coordination of these solutions, which of course, act on both the back-end and the front-end. The final dynamic capability that also works both ways is understanding consumers and the market. The resources affecting the front-end processes include the sales area, while back-end resources include warehouses, financial resources and operational resources. Both back-end and front-end are represented by human resources and products. (Mrutzek-Hartmann et al. 2022). Solem et al. (2022) identified eight dynamic capabilities that are necessary to develop an omnichannel strategy and grouped them into four categories. These dynamic capabilities are the following:

1. Capabilities related to back-end technologies

- Capability to develop and implement an integrated digital ERP system.

- Capability to optimize online business, mobile usage, connectivity with social media platforms, and search engine optimization.

2. Capabilities related to optimizing the consumer experience

- Capability to optimize the efficiency of product delivery, return policies, and supply chain management

- Ability to deliver the customer experience in a physical environment, like through showrooms and pop-up stores

3. Capabilities related to external and internal collaboration

- Capability to collaborate across multiple business units and strengthen the core management team

- Capability to collaborate with retail suppliers and partners across different service ecosystems

4. Capabilities related to standard omnichannel operations

- Capability to build and maintain a consumer-oriented retail culture

- Ability to integrate marketing communications and personalization through the use of data

Based on the works of Mrutzek-Hartmann et al. (2022) and Solem et al. (2022), the dynamic capabilities and resources that are essential for a successful omnichannel strategy can be determined. Technologies like the Internet of Things, artificial intelligence, cloud computing, big data, blockchain, augmented reality, advanced robotics, additive manufacturing technologies, simulation, and semantic technologies have attributes that define the digital capabilities of a company, becoming the inducers of digital transformation (Chirumalla 2021).

The impact of these technologies on omnichannel strategies is, therefore, a relevant topic, and better understanding and research are essential to getting acquainted with these technologies. We need to be able to better map their impact on strategy, examine the capabilities and resources required to successfully implement them, and see how they contribute to value creation.

2 Robots

Among the Industry 4.0 technologies identified by Rußmann et al. (2015), advanced robotics stands out. In their interpretation, these industrial robots differ from the mainstream industrial robots that have appeared throughout history in that they are autonomous, flexible, and cooperative. They are autonomous because they can make decisions based on prior algorithms. They are flexible because they are capable of multi-tasking and more mobile than their predecessors were generations ago. And they are cooperative because they can reach and maintain deeper levels of human-robot collaboration. The increasing popularity of industrial robots is also due to the fact that they are now seen as an Industry 4.0 technology and not just an example of industrial automation. Thanks to their exponential technological nature, the cost of industrial robots is constantly decreasing, and their technical capabilities are becoming more versatile, which is also why they are becoming more widespread. Due to cost reduction and versatility of use, SMEs can nowadays afford to invest in such solutions (Strange & Zucchella 2017).

We can further divide service robots into three different parts: personal, professional, and collaborative service robots (Galin et al. 2020) (Figure 4). Professional service robots, due to their consumer orientation, are regarded as being more prevalent in the front-end domain. Collaborative service robots are usually deployed in the back-end. Industrial robots are excluded from our research in the retail environment because of their primary role in production, and personal service robots are not examined further there either, as they are consumer-use robots.

INSERT FIGURE 4 HERE

In Pistrui & Harmat (2022), the authors examine how these service robots have spread across multiple industries and how these features are observed in service robots. According to their definition, "physically embodied or software robots with a high level of artificial intelligence and social skills that are different in appearance from industrial robots are called service robots." (Pistrui & Harmat 2022, p. 64) This definition builds on Wirtz et al.'s (2018, p. 909) definition of service robots as "system-based autonomous and adaptable interfaces that interact, communicate, and deliver service to an organization's customers".

3 Service robots in retail

In the past decade, the application of robots and other technologies has accelerated the digital transformation of the retail sector. The total value of robots in retail reached $19 billion in 2015, and at that time, a steady average annual growth rate of 11% was predicted, which would lead to a market size of $52 billion by 2025. This growth was driven by the proliferation of robots in retail and the steady decrease in the prices of goods (Bloching, 2016). The growing importance of robots in the retail sector was so evident that the first conference at Northwestern University in 2018 was held, which focused solely on retail robotics and the potential of artificial intelligence (Bogue, 2019).

Today, the evident growth of the technology's adoption is driven by the implementation of service robots. Sales of these service robots grew by 37% in 2021, indicating the huge potential companies see in such devices (IFR, 2022). Behind this growth, the increasing digitalization of retail plays a role. The World Economic Forum's article cites Mark Shirley, Head of Logistics at Primark, stating that "the sector is already 40% automated, but this could jump to 60–65% over the next three to four years" (World Economic Forum, 2022).

In the retail sector, the biggest companies are leading the way towards innovation. This is the outcome of the constant competition between physical stores (Walmart) and e-commerce (Amazon). This means that they are successfully adapting to the digital revolution in today's competitive environment and developing new strategies to counter the expansion of e-commerce giant Amazon. They exploit the latest technologies and benefit from the resulting synergies (Makridakis 2017, Investopedia 2019). The physical stores of larger retailers will remain competitive but will rely heavily on technologies such as artificial intelligence and robotics in the future. This could mean lower employment costs for these retailers. The only advantage for competing smaller firms is that they can build on their personal ties between their employees and their customers (Shankar 2018, Bertacchini et al. 2017).

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Front-end processes

Regarding front-end activities, two important areas need to be distinguished. The first is the state of the store, its maintenance, and related activities.

The process of cleaning shops and signalling potentially dangerous situations is mentioned in literature in the context of robotization in retail. After the store closes, 20% of employees' time is spent on cleaning, which could be used for other work. This problem is strongly linked to hazardous situations, examples of which range from simple liquid spills to potentially more serious problems that could be detected by sensors attached to robots. These robots, which can clean and detect hazards, are mainly autonomous. In addition to their main function, they can also check stocks, prices, and planogram compliance, supporting both front-end and back-end activities (Bogue 2019).

The second area of front-end activities is customer-facing activities. Instead of collaborative robots, this field deploys professional robots that can interact with consumers moving around the sales area to enhance the customer experience. This poses the question already raised by Singh (2019): what will be the impact on consumers if a robot performs an activity previously performed by a human? On the customer side, the real issue is trust. The 'Uncanny Valley' theory, however, predicts that human-like robots will gain more acceptance from humans than machine-like ones, but this could backfire if they become too similar to humans. Machine-like robots may also gain trust by behaving like humans. Acceptance also depends on customers' experiences with technology (Ben Mimoun et al., 2012; Lu et al., 2019; Wingreen et al., 2019).

A robotic assistant that meets shoppers' expectations can be a great help for shopping by building on the benefits for both the stores and customers. These robotic assistants can also be embodied as robotic shopping trolleys, which can be a great help for elderly or disabled people to carry their belongings or for other shoppers to find the products they need in stores (Bertacchini et al. 2017, Bogue 2019).

In addition to robotic carts, they can also provide personalized customer service and other value-added services (self-checkout cashiers, avoiding shelf abandonment) (Kumar 2016). These personalized services are based on data collected by sensor robots. Such data can include the age, gender, behavioral patterns, shopping history, etc. of the customer, and the robot can recommend products to customers in stores based on the gathered and analyzed data. In conclusion, robotics can be a solution for product personalization, which is highly demanded by consumers today. They can even order a fully customized product through an app, which will be prepared by a complex, cloud-based robotic system (Zhang et al. 2019).

These activities can increase the amount of time shoppers spend in front of shelves, which can lead to an increased customer propensity to purchase (Bertacchini et al. 2017). AI-powered robots can further improve service quality, customer-robot interaction, and AI-assisted decision-making as well (Shankar 2018). Using machine learning technology, the robots collect data during the customer-robot interaction process and analyze it to gain further insight into possible process failures. In this case, they can warn their owners to buy them new parts or clothes so that they can continue their service and, through that, increase the customers' willingness to buy (Gonzales-Jimenez 2018).

In addition to the positive effects, some researchers are concerned about the possible impact of the technologies. For example, as human interpersonal relationships are affected by human-machine interaction (Priporas et al. 2017), even the return on investment in robot technology is questioned by some (they focus mainly on the two sides of investment, maintenance, and employee wages, but many completely neglect to gauge the positive returns regarding the impact on the customer experience).

Back-end processes

The use of robotics in back-end activities has the same broad potential as in front-end activities, especially in replacing human labour. In back-end activities, collaborative robots can replace personnel, reducing costs and increasing warehousing performance (Bertacchini et al. 2017).

These benefits are mainly driven by the technological background of customized products, back-office administrative activities in warehousing and inventory management, autonomous delivery options, and last-mile delivery systems.

The replacement of back-end tasks is particularly important, as sales assistants spend around 30% of their time on back-office tasks. Much of this work can be easily automated, freeing up some time for employees to do more and better sales work so that they can deal with customers instead of administrative tasks (Bloching 2016). By freeing up time for sales assistants to do value-added work and focus on integral parts of everyday work, compassion and customer-orientation mechanisms will also have a greater effect on businesses being successful, which are proven to be essential in how customers are served (Zoghbi-Manrique-de-Lara et al., 2023). Through working in a compassion-driven and ethical environment, employees are motivated to adopt an honest approach and stay engaged in a store's sales setting (Ruiz-Palomino et al., 2023).

Inventory management and stocking will be significantly more efficient with AI-powered robotics. Based on the data collected and analyzed, experts can develop predictive models for robots, which can then manage the stocking, inventory, and ordering processes all on their own. Thus, these robots can ensure that customers have access to the desired products when they want them (Shankar 2018). Robots can be useful not only in store warehouses but also in large logistics centers. With minimal human or automated intervention, they can achieve higher levels of efficiency (Vallandingham et al., 2018). Robots in warehouse environments can perform a wide range of tasks. Robots moving along shelves are just the beginning (Boysen et al., 2019). Exotec Solution, a French robotics company, has developed a machine that can climb onto racks, pick up orders, and even deliver them to the specified location (Mahroof 2019). In addition, wearable robotics with various exoskeletons are key to helping human workers avoid injuries from heavy lifting during warehouse operations while also increasing efficiency (Tang & Veelenturf 2019). There are also many examples of fully automated warehouses that operate with minimal human labour but maximize space utilization, working 24 hours a day for all seven days of the week. (KPMG 2018, Bloching 2016). The first fully operational, fully automated warehouse was installed by JD.com in Shanghai in 2019 (Tang & Veelenturf 2019), but other major retailers are also experimenting with the technology.

Connected to retail, there are several experiments in the transportation industry, including a wave started in 2013 by Amazon with the intention of introducing a drone delivery system. As a result, retailers such as Walmart and delivery businesses such as UPS and FedEx have sought partnerships and launched autonomous delivery projects using drones and vans. Some companies have even ventured into developing their own automated retail stores (Bogue 2019). The aim of autonomous last-mile delivery systems is simple but difficult to achieve. The customer simply places an order for the desired product, and the order is processed through an autonomous system that is linked to the autonomous warehouse mentioned above. Then, the system delivers the order with autonomous delivery within a few hours of the order (Deloitte 2018, Bogue 2019).

Key enablers

Any company that wants to achieve results from robotics must meet certain requirements. The first factor is the organization, which must support the implementation of robotic technology. Employees must see the positive side and not be afraid of technology that could take their jobs away (Bagdasarov et al. 2018, Priporas et al. 2017). In 2017, Frey & Osborne calculated the potential for automation in a total of 702 occupations. According to their calculation, the sales job in retail is at the highest risk. In a retail environment, humans need to supervise and support robots during their interactions with customers. The question is: what level of automation is needed to maximize value creation? In turn, robots can assist employees by performing automated, repetitive work instead of them (Daniela 2015). Advances in sensing and communication technologies ensure that robots and humans can work together safely (Tang & Veelenturf 2019).

On the other hand, a company needs to invest not only in robotics but also in technology and infrastructure support. Data can play an enabling role in robotics in a technology-rich retail environment (Bertacchini et al., 2017, Colangelo & Maggiolino, 2019). To maximize synergies, companies must also consider integrated technologies and continuously improve their IT infrastructure. With the right combination of big data, AI, drone technology, machine learning, and cloud computing, company-tailored robotics can serve as the key to success in today's competitive retail market.

4 Methodology

Our research is based on the document analysis of articles from three news portals with a focus on retail. Corbin & Strauss (2008) define document analysis as "a systematic process for reviewing or evaluating documents, both print and electronic (computer-based and Internet-delivered)." Such documents include, but are not limited to, advertisements, handbooks, background documentation, brochures, diaries, journals, event programs, letters and memos, maps, charts, newspaper press releases, organizational or institutional reports, and questionnaire data (Bowen, 2009). The choice of this method is essential for the study of the uptake of robots since fieldwork and observation are not feasible, as the basis of the presented research is analyzing the global context of robotic technology. By examining materials from large companies and press articles, a comprehensive picture can be obtained.

To maintain a geographically diverse pool of the analyzed companies, we present retail examples from three different sites that cover retail operations in the United States, Asia, and Europe.

INSERT FIGURE 5 HERE

Our research model can be seen in Figure 5. For the first filtering steps, we used only the keyword “robot” to determine the main pool of articles to examine (440, 119, and 449 articles, respectively). To continue with the document analysis of the articles, we have chosen three keywords, including “robot”, "automation,” and "omnichannel,” to filter for the type of technology and sector, so only relevant articles will be included in the document analysis. We used the term “omnichannel” to include companies that are successful in integrating front-end and back-end technologies, as they are likely to have already adopted several digital technologies in their operation.

The online retail news site “Retailwire.com” was chosen because the sources of its articles are large multinational retail sites and popular business magazines (e.g., Forbes, Business Insider). The site also has a state-of-the-art search engine ideal for systematic keyword searches. The unique feature of the site is that it only allows authorized retail industry experts to open a discussion, which helps us to ensure the validity of the article pool. On this page, we found 440 articles based on keyword searches, of which 103 were selected for our research after filtering them.

The other two sites chosen were “Retailnews.asia” and “Retail Detail.Eu”. The reasons for our choice are very similar to those already presented for “Retailwire.com”, as they are suitable for keyword searches and aggregated documents from typical retail news portals. Using the three sites combined, we created a pool of continent-based retail articles, which helped us target the selection process for certain geographical areas. On “Retailnews.asia”, where retail articles were included relevant to the Asian market, 449 relevant articles were identified, of which 62 were selected. On “Retail Detail.Eu,” which collects retail articles based on the European retail market, 25 out of 119 were selected. To determine the final pool of retail articles that describe how certain companies apply robotic technology in their operations, we only kept articles describing solutions that were already implemented at the time this paper was finalized. We also filtered out duplicated company cases and articles without a specific focus; hence, a final number of 48 company examples was reached and is being presented here.

To frame our research, Section 5 analyzes the role of robotic technology in retail by using two digital transformation models of dynamic capabilities, introduced by Mrutzek-Hartmann et al. (2022) and Solem et al. (2022) and explained in Section 1. By examining the service robots of retail companies in the context of both models, key dynamic capabilities were identified that enable retailers to sustain their advantage in the ever-intensifying competition of the retail sector.

These key dynamic capabilities are shown in the first column of Tables 1 and 2, structured by the two previously mentioned digital transformation models. The 48 chosen company examples were placed in the “geographical breakdown of companies” columns of Tables 1 and 2, according to their retail database source.

Lastly, we conducted a two-step validation of our research. Firstly, we took the publications presented in Section 3. Secondly, an additional keyword and context search was carried out in journals within the ScienceDirect database. To select relevant journals and articles to enhance the quality of the validation, we used “retail AND robots” AND “dynamic capabilities”” in the

logic of Boolean operators to filter for the applicable articles in the database. These articles were placed in the second column of Tables 1 and 2 (“Examples from academic literature"), matching the respective dynamic capabilities.

5 Dynamic capabilities and robots in retail

In Teece's (2018) simplified model, the three main stages of dynamic capabilities are sensing, seizing, and transforming. Warner & Wägner (2019) interpret dynamic capabilities in the digital environment. Digital sensing is about exploring business opportunities, while digital seizing is about designing the right elements of the business model. Lastly, digital transformation is about reconfiguring internal processes, shaping the business model, and developing digital maturity. We identified retail robots as tools for digital transformation, so our research focuses on the third phase.

We can evaluate business examples in retail through dynamic capabilities using the categories defined by both Mrutzek-Hartmann et al. (2022) and Solem et al. (2022), described earlier in Section 1, and organizing the selected academic and news portal articles (see Section 3) within these categories. Tables 1 and 2 below summarize these practical examples according to the related literature and geographical breakdown.

INSERT TABLE 1 HERE

INSERT TABLE 2 HERE

The coverage of retail robots in literature is extensive, such as their place in the lives and business models of companies, as shown in both Table 1 and Table 2. While supply chain integration was the key factor in the 1990s, from the late 2000s onwards, consumer adaptation of digital devices and emerging technologies came to the spotlight for retail. Today, this includes, among other things, the introduction of artificial intelligence-based solutions and retail robots. They provide a strong foundation for the digital maturity of companies (Hanninen et al., 2020), while the alignment of back-end and front-end processes is necessary for seamless operations, to which a comprehensive digital technology portfolio serves as a great enhancement (Ye et al., 2022). Many authors argue that to become technology pioneers and market leaders, businesses must invest in capabilities that involve robotics and artificial intelligence that will support the value proposition for the consumer (Leroi-Werelds et al., 2021) and that the COVID-19 pandemic has only accelerated the adoption of such technologies after social distancing practices had been in place for a long time (Hoekstra & Leeflang, 2022).

The ability to integrate business processes is a key to success for retailers, which is fostered by AI-enabled service innovations such as robots (Akter et al., 2023).

In addition to research on omnichannel environments and consumer experience, the use of retail robots in supply chain management is the most studied area in the literature. In retail, the monitoring of both product availability on the shelves in the sales area and the stock levels in the warehouse area is considered feasible (Morenza-Cinos et al., 2019). On the front end, Carnegie Mellon University's bookstore, Schnucks, Sam's Club, and Walmart supermarket chains successfully use professional robots to scan products on the shelf. These robots monitor and check the availability and stock levels of products in the sales area. The application of retail robots for this purpose can also filter misplaced products, even if they did not receive product placement information beforehand (Solti et al., 2018). A significant advantage of such applications is that AI-enabled shelf-scanning robots can enhance the efficiency of sales assistants (Mordai & Dass, 2022). On the back-end, companies are using robots to run automated warehouses. Robots developed by Ocado can be found in retail chains around the world, from Kroger in the US and Sobeys in Canada to French retailers Casino, Morrison's in the UK, and ICA in Sweden, where they contribute to back-end process efficiency. Similarly, Scallog robots and Tesco mini-repositories support back-end operations too.

The establishment of fulfillment centers is also a prominent practice at many large retail companies. In 2012, Amazon acquired Kiva, which allows them to use robots to move stock in their warehouses. Hudson Bay Company (HBC) has also opted for fulfillment centers, which they claim make their operations three times more efficient. In addition to these, GreyOrange's widespread Butler robotics system, Walmart and Lord & Taylor are also successful examples of fulfillment centers. As for the stage of the supply chain management closest to the consumer, retailers are embracing innovative ways of going the "last mile". This is of paramount importance, as the „last mile” experience has a significant impact on consumer satisfaction (Vakulenko et al, 2019). The challenge of this stage can be overcome by using self-driving cars, as demonstrated by the use of Nuro self-driving cars in the delivery of retail giant Kroger, or the self-driving truck patented by Google. This same solution is chosen by supermarket H-E-B too.

The satisfaction and in-store experience of the "new consumer" are influenced by multiple elements, to which technological support contributes significantly (Bäckström and Johansson, 2017). In line with this, the shift in literature and retail business models towards omnichannel strategies is undeniable (Hanninen et al., 2020). The robots that create and maintain this environment are typically located in the retail sales area in a highly visible way, as they are at the heart of the omnichannel model of companies. An example of this can be seen in Zara's stores in North America and Europe. Robots in the out-of-store fitting rooms allow customers to collect their online orders in the store. At Hointer, on the other hand, an app makes shopping easier in the in-store space: products placed in the virtual shopping cart are delivered to the in-store fitting room, so the robots are working outside the consumer's field of vision, "in the background". Walmart has patented its self-driving shopping trolleys as an innovation to simplify the shopping process. Consumers can call the trolleys equipped with sensors and cameras using their smartphone apps. This way, the chain not only enhances the omnichannel experience for consumers but also makes in-store service more efficient. A similar innovation

is the Aircart bookstore's smart robotic shopping trolley, which amplifies the customer's pushing power, making in-store navigation easier. In addition to corporate examples, shopping malls with retail outlets are also using robots to engage shoppers: click-and-collect robots at Funan in Singapore and the full omnichannel architecture at JD Mall in China can integrate different stores to maximize the customer experience. In Europe, order dispatch and pick-up are seen to be managed by robots; the robotic pick-up points at Ochama and Carrefour are pioneer examples of this. The cosmetics company Rituals uses QR codes to receive orders from queuing customers, which can be picked up by them after they have entered the store.

By deploying retail robots, which can access business databases or social media in the store area, one can also provide consumers with a personalized experience by filtering their preferences (Bertacchini et al., 2017). There are many examples of robot customer service. Leading the way are Toshiba's Aiko Chichira service robot and assistant robots at Lowe's and Macy's, which can answer consumer questions and guide them to the product they are looking for. Media Markt's Pepper robot in Eindhoven can also guide and serve customers in-store, while WiiGo robots assist shoppers at Auchan in Western Europe.

A similar function is performed by robots placed in shopping malls, such as the Chichira Junco robot at AquaCity and the Sam robot at SM Megamall. Robots placed to attract attention also rely on interacting with consumers and are effective in luring potential customers to the store (De Gauquier et al., 2021). Greeting robots can be found in several Macy's stores and in Lenta stores in the Russian capital. Also, Toys R Us toy stores have successfully used their My Keepon robots as an attraction. The Pepsi Co. advertising robots tested in Carrefour stores in Poland are also building on their power to attract attention. What all these robots have in common is that they rely on interaction with the consumer.

It is important to distinguish between two types of interaction between robots and humans: direct and indirect. Greeting robots and customer engagement robots target consumers in a direct way, creating a lasting customer experience. The Tokinomo marketing robot and the playful NAO robots of SmarTone aim to enhance the customer experience. The Probe robot at the Gentle Monster store in Shanghai features a digital creature resembling a six-legged being that embodies the essence of the brand. UV disinfection robots have also emerged because of the coronavirus pandemic, which, unlike the previous examples, interacts with consumers indirectly. The robots can also take over the tasks of the shop assistants (Wolpert & Roth, 2017). Supermarket chain Giant Foods uses its robotic assistants, called Marty, primarily to predict in-store emergencies. Through this, store employees can pay more attention to serving customers. There are also many examples of fully automated stores; the Solebox store in Berlin operates without a human workforce. Although 100% automation is not yet common in the sales area, more and more practices are emerging around the world to replace human resources: kangaroo-shaped robots at FamilyMart in Thailand can even do shelf sorting. A very different concept from the previous ones is the CLOi wearable robot, a piece of equipment that helps business salespeople work more efficiently.

Along with improving the customer experience, a deeper understanding of consumers is an important benefit of using retail robots and emerging technologies (Lavoye et al., 2021). Examples from our research also support the idea that this requires outsourced robots to have higher social competence, human personality traits, and to be adaptive. These make the consumer-robot relationship easier to establish (Song & Kim, 2020). Anthropomorphism and

the social traits of robots are more important to discuss in retail than in other sectors. Although consumers are encouraged to approach these robots as service providers, excessive anthropomorphism may create a negative impression on consumers (Lu et al., 2018).

6 Validity and limitations

In order to ensure validity, we matched our research results based on information collected from retail news sites with the articles used in Section 3 and further strengthened this process by including additional articles in Tables 1 and 2 as described in Section 4. Validity can be further increased by a systematic search based on articles from the major retail journals, by processing more articles with the relaxed keyword search rule already described in Section 4, and by conducting interviews with experts in retail digital transformation.

Reproduction of the research might be a bit more tedious due to the fact that one of the used retail news portals, „Retailwire.com," modified its search engine some time ago, requiring more effort to access their older articles.

One limitation of our research is that we did not conduct a complete survey of all available retail news sites; we just focused on some geographically important and relevant major ones. A complete survey could further strengthen our results by finding and including more company examples. We also did not dive into analyzing possible regional differences in detail, as this would have been beyond the scope of this article. This extension could be the start of a new research direction, as well as the inclusion of other, so far not covered geographical regions.

Conclusion

Our research investigated the dynamic capabilities required for the successful implementation and integration of service robots into business processes in retail. Mrutzek-Hartmann et al. (2022) and Solem et al. (2022) both defined the dynamic capabilities that retail companies can build on to develop a successful omnichannel strategy. The example of robotic technologies can be extended to other digital technologies because of their technology-integrating complexity. With our research, we would like to provide a new perspective for academics working on the digitalization of retail. An analysis of dynamic capabilities and technology implementation can provide further support for a better understanding of the ongoing digital transformation in retail, which is still a work in progress.

The level and focus of implementation of robot technology vary across the markets researched. In general, retail companies are largely using service robots to enhance the customer experience. In this regard, it is noteworthy that companies are using robots to harmonize their physical and digital environments, leveraging the dynamic capabilities of consumer interactions and maintaining an omnichannel environment. Asian retailers are well ahead in this area, with the vast majority of the surveyed companies already having deployed service robots. In comparison, Europe and the US are more balanced in terms of using robots in their front-end

and back-end activities. As far as back-end processes are concerned, service robots are most common in the warehouses linked to the sales area. Companies can successfully implement robots by building on their dynamic capabilities in supply chain management and back-end process integration.

The successful implementation of service robots could have a strengthening effect on dynamic capabilities, potentially enhancing the digital sensing capabilities of retail companies. It is possible through gaining a deeper understanding of consumers, which also outlines further research directions. Further research could include in-depth interviews with experts and case study-like research with companies at the forefront of digital transformation in retail. The selected news portals have great potential for document analysis since only academic and industry experts can add posts and write articles on them. The focus of research would be on consumer and company-level adoption of robotic technologies and the impact of robotic technologies on the consumer experience. Questions that could be raised may target different areas. Firstly, can the adoption of robot technology help improve the efficiency of retail companies in both front-end and back-end operations? Also, is it a temporary positive effect due to novelty, or can the use of robots on the front-end be a source of sustainable competitive advantage? As an additional research direction reflecting on the positive effect of servant leadership in strategic differentiation (Ruiz-Palomino et al., 2021), it could be examined whether service robots could take a facilitative role between managers and subordinates and how they can encourage collaboration and social interactions between different business functions. Connected to this, it is interesting to analyze how service robots can contribute to building social capital at firms and, by doing so, yield a competitive edge for the business (Zoghbi-Manrique-de-Lara & Ruiz-Palomino, 2019).

The widespread adoption of service robots in retail is still a long way from maturity. Through analyzing various company examples, we have seen that retailers are using robots in both their front-end and back-end operations, primarily to enhance the customer experience. Companies can leverage their dynamic capabilities to successfully introduce and integrate service robots into their operations. By analyzing the 48 company examples presented in our paper, several practical conclusions can be derived for business owners and managers. Robotics work most efficiently when used to enhance the customer experience and integrate both front-end and back-end operations. These technologies provide invaluable benefits when retailers would like to get insights from customer interactions, thus improving the sensing and dynamic capabilities of the business.

To conclude, our research can provide companies with a clear focus on the dynamic capabilities and business areas in which they can successfully implement service robots. Our results can also provide the research community with potential new opportunities to conduct future research.

Data availability statement

The data that support the findings of this study are available from the corresponding author, M. Zs., upon reasonable request.

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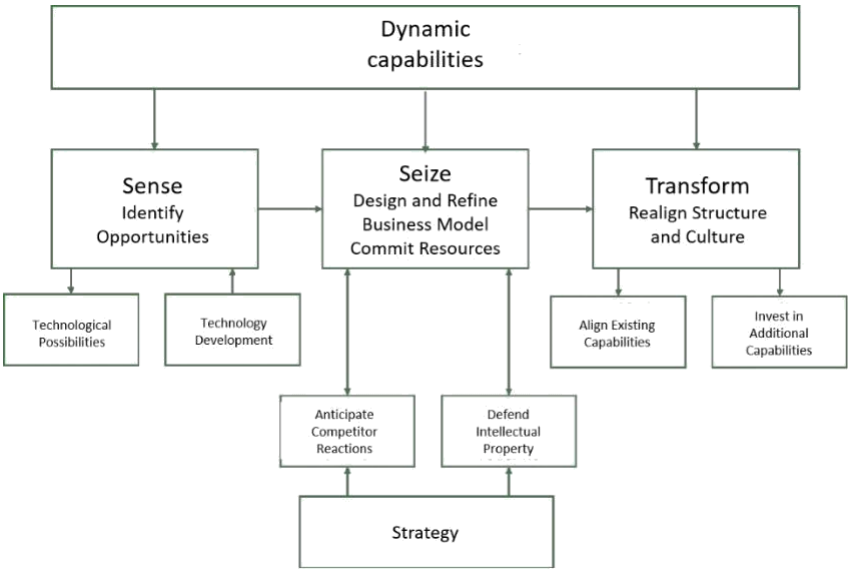
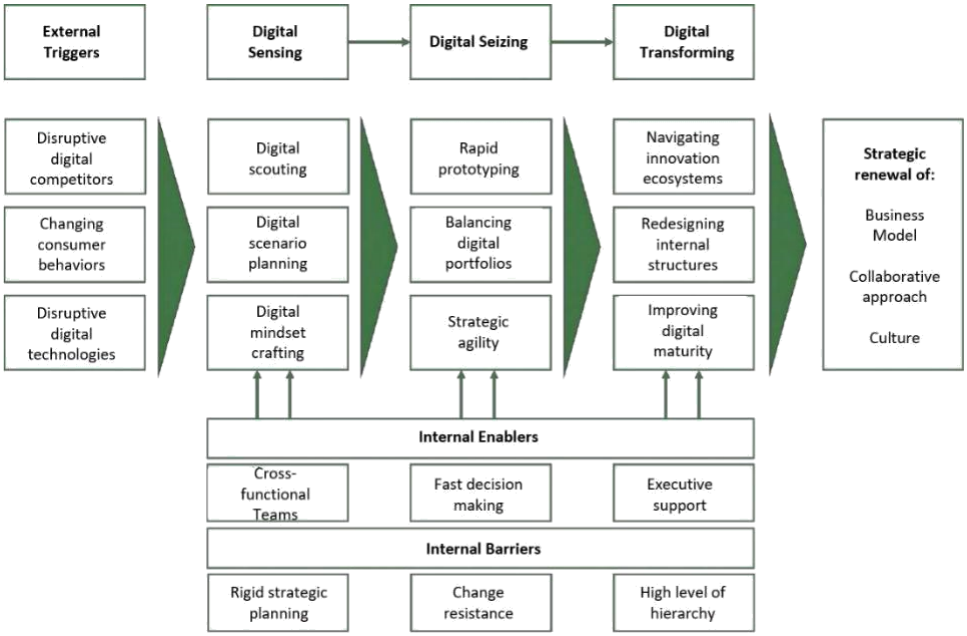
Figure 1. A simplified model of dynamic capabilities in relation to strategy and business models



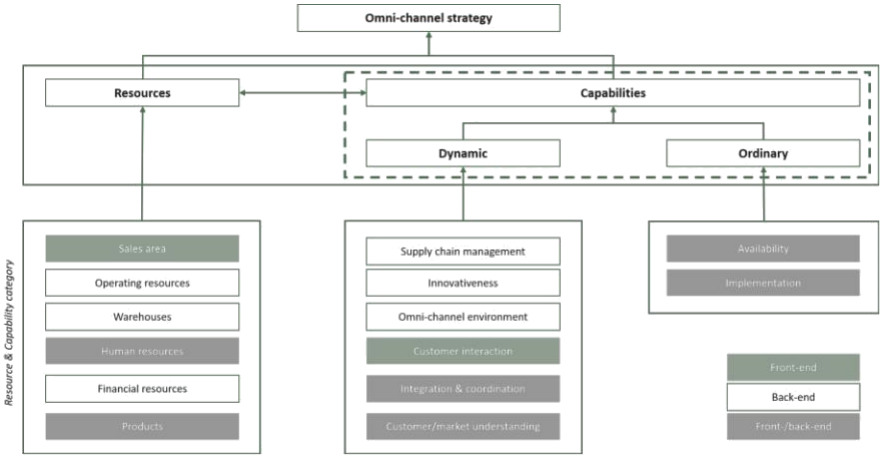
Source: Teece (2018)

Figure 2. Building dynamic capabilities for digital transformation: A process model.



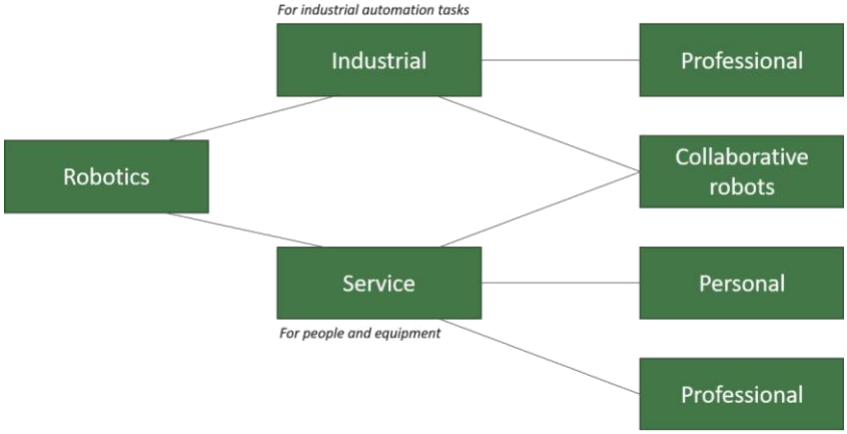
Source: Warner & Wägner (2019)

Figure 3. A conceptual framework of resources and capabilities for developing a retail omnichannel strategy



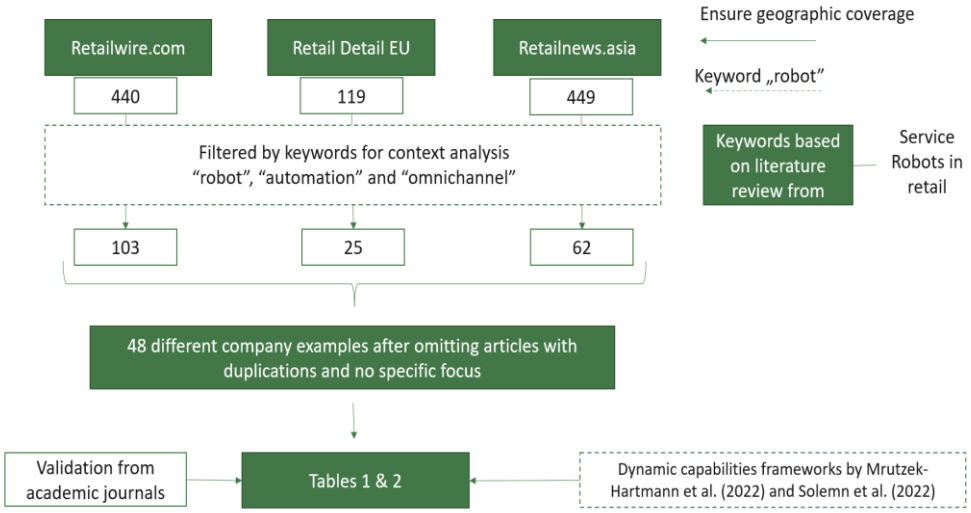
Source: Mrutzek-Hartmann et al. 2022

Figure 4. Classification of robots



Source: Galin et al. (2020)

Figure 5. Research design



Source: own work

Table 1. Service robots and dynamic capabilities at retail companies based on the categorization of Mrutzek-Hartmann et al. (2022)

		Geographical breakdown of companies		
	Examples from academic literature	**Retailwire examples**	**Retail Detail EU examples**	**Retailnews.asia examples**
Dynamic capabilities (Mrutzek et al, 2020)		**Company (Name of robot/Manufacturer)**	**Company (Name of robot/Manufacturer)**	**Company (Name of robot/Manufacturer)**
Supply chain management	Wolpert & Roth (2017), Hanninen et al (2020), Backström & Johansson (2017), Ye et al (2022), Mordai & Dass (2022)	Carnegie Mellon University bookstore (AndyVision), Walmart (Auto-S), Kroger & Sobeys (Ocado), Schnucks (Tally), Sam's Club (Brian Corporation), Amazon (Kiva), Lord & Taylor fulfillment center, Walmart fulfllment center, GreyOrange Butler fulfillment center	Casino, Morrison's, ICA (Ocado), Colruyt (Scallog), Tesco (Mini-repository)	
Innovativity	Vakulenko et al (2019), Morenza-Cinos et al (2019)	Kroger (Nuro), Google patented self-driving truck, H-E-B self-driving delivery vehicle		
Omnichannel environment	Hanninen et al (2020)	Hointer, Zara, Walmart (Robo-cart	Ochama (pick-up point), Carrefour (pick-up-point), Rituals, Zara Stratford store	Funan shopping mall (Click-and-Collect), JD Mall shopping centre
Customer interactions	Bertacchini et al (2017), Song & Kim (2020)	Lowe's (LoweBot), Toys "R" Us (MyKeepon), Macy's (Marty)	Solebox (Solebot), Media Markt Eindhoven (Pepper), Auchan (WiiGo), Carrefour-Pepsi Co marketing robot, Lenta (Promobot)	Mitsukochi (Aiko Chihira), Aqua City (Chihira Junco), Aircart bookstore, Tokinomo, SmarTone (NAO), SM Group-SM Megamall (Sam), Center Food Hall (UV-C), Nudaku (The Probe), Pricerite (Pepper)
Integration and coordination	Solti et al (2018)	Giant Food's, Stop Shop és Martin's (Marty)		FamilyMart Funan shoping mall (M1), CLOi
Understanding consumers and markets	Song & Kim (2020), Backström & Johansson (2017), Hoekstra & Leeflang (2022)	Lowe's (LoweBot), Toys "R" Us (MyKeepon), Macy's (Marty)	Solebox (Solebot), Media Markt Eindhoven (Pepper), Auchan (WiiGo), Carrefour-Pepsi Co marketing robot, Lenta (Promobot)	Mitsukochi (Aiko Chihira), Aqua City (Chihira Junco), Aircart bookstore, Tokinomo, SmarTone (NAO), SM Group-SM Megamall (Sam), Center Food Hall (UV-C), Nudaku (The Probe), Pricerite (Pepper)

Source: Own editing based on „retailwire.com", „Retail Detail.Eu" and „Retailnews.asia" articles

Table 2. Service robots and dynamic capabilities at retail companies based on the categorization of Solem et al. (2022)

		Geographical breakdown of companies		
	Examples from academic literature	**Retailwire examples**	**Retail Detail EU examples**	**Retailnews.asia examples**
Dynamic capabilities (Solem et al, 2022)		**Company (Name of robot/Manufacturer)**	**Company (Name of robot/Manufacturer)**	**Company (Name of robot/Manufacturer)**
Capabilities related to back-end technologies		Giant Food's, Stop Shop és Martin's (Marty), Amazon (Kiva), Carnegie Mellon University bookstore (AndyVision), Walmart (Auto-S), Kroger & Sobeys (Ocado), Schnucks (Tally), Sam's Club (Brian Corporation), Amazon (Kiva)	Casino, Morrison's, ICA (Ocado), Colruyt (Scallog), Tesco (Mini-repository)	Funan shopping mall (M1), CLOi
Capabilities related to optimizing consumer experience	Lavoye et al (2021), De Gauquier et al (2021), Leroi-Werelds (2021)	Toys "R" Us (MyKeepon), Lord & Taylor fulfillment center, Walmart fulfillment center, GreyOrange Butler fulfillment center, Lowe's (LoweBot), Macy's (Marty), Kroger (Nuro), Google patented self-driving truck, H-E-B self-driving delivery vehicle	Solebox (Solebot), Media Markt Eindhoven (Pepper), Auchan (WiiGo), Carrefour-Pepsi Co marketing robot, Lenta (Promobot)	Mitsukochi (Aiko Chihira), Aqua City (Chihira Junco), Aircart bookstore, Tokinomo, SmarTone (NAO), SM Group-SM Megamall (Sam), Center Food Hall (UV-C), Nudaku (The Probe), Pricerite (Pepper)
Capabilities related to external and internal collaboration				
Capabilities related to standard omnichannel operations	Hanninen et al (2020), Akter et al (2023)	Hointer, Zara, Walmart (Robo-cart	Ochama (pick-up point), Carrefour (pick-up-point), Rituals, Zara Stratford store	Funan shopping mall (Click-and-Collect), JD Mall shopping centre

Source: Own editing based on „retailwire.com", „Retail Detail.Eu" and „Retailnews.asia" articles