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Work Project – Digital Supply Chain Management

Digital Technologies Catalyzing Business Model Innovation in Supply Chain Management – The Case of Parcel Lockers as a Solution for Improving Sustainable City Mobility

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Abstract

The rise of information technologies pushes companies into digital restructuring. Organizations integrating emerging technologies into their supply chains can boost efficiency by streamlining processes and making more informed decisions using predictive analytics. This research discusses major enablers for digital transformation and presents the application of those along different parts of a digital supply chain, while focusing on technical characteristics, implementations, and impact on organizational capabilities and strategies. The parcel lockers are a technology that sustains and improves last-mile delivery. By combining it with night-time delivery improves the City's Sustainable Mobility and, therefore, reduces the local emissions and city congestion.

Keywords: Digital Supply Chain Management, Supply Chain Management, Digital Transformation, E-commerce, Parcel Locker, Night-time Delivery, Technology Adoption

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List of Abbreviations

AOV	Average Order Value
API	Application Programming Interchange
AI	Artificial Intelligence
B2B	Business to Business
B2C	Business to Consumer
CAC	Customer Acquisition Cost
CAGR	Compounded Annual Growth Rate
CBF	Content-based Filtering
CLF	Collaborative Filtering
CLV	Customer Lifetime Value
DS	Data Science
ERP	Enterprise Resource Planning
ET	Emerging Technology
EV	Electrical Vehicles
FMCG	Fast Moving Consumer Goods
GPS	Global Positioning System
HRS	Hybrid Recommender System
ICT	Information and Communication Technologies
IoT	Internet of Things
KPI	Key Performance Indicator
M&A	Mergers and Acquisitions
MFC	Micro Fulfilment Center
ML	Machine Learning
MRP	Materials Requirement Planning
NPS	Net Promoter Score
NTD	Night-time Delivery
P2P	Procure-to-pay
PL	Parcel Lockers
PO	Purchase Order
RFID	Radio-Frequency Identification
RfP	Request for Proposal
RPA	Robotic Process Automation
RQ	Research Question
RS	Recommender System
SC	Supply Chain
SCM	Supply Chain Management
SKU	Stock Keeping Unit
UFT	Urban Freight Transport
UX	User Experience
VC	Venture Capital
WMS	Warehouse Management System
3PL	Third Party Logistics

1 Introduction

As early as 1996, Lowe et al. predicted that the internet would evolve from a mere research resource to a global information network, offering a wide range of service opportunities (Lowe et al., 1996). Today, more than 20 years later, the evolution of the internet and recent technology developments have undoubtedly changed the way of working (O'Halloran 2015) and brought new dimensions to supply chain management (SCM) (Poirier and Bauer 2000).

Due to the nature of globalization, growth of business models, and rapid advancements in digital technologies, modern supply chains (SCs) are characterized by tight market conditions, geographical disparity, and uncertainty (Deloitte 2017). To survive in this global market, organizations need to identify emerging technologies (ETs) that can be used to maintain or develop a competitive advantage through new business models (Prakash and Rakesh 2018). Therefore, many companies are constantly reviewing processes to discover better practices for managing their SC data (Deloitte 2017). Data-derived insights are considered as a tool to improve SC performance. Concepts of ETs, such as Big Data and Advanced Analytics offer decision-making practices that enhance process-level performance (Ramanathan et al. 2017). ETs are captured in Industry 4.0, describing the convergence of information and communication technologies (ICT) and machine automation (B. Nicoletti 2017). Both academics and practitioners use Industry 4.0 to predict future events (Lu 2017). Further, research shows evidence that firms deploy digital technologies to manage the SC from a technical, organizational, and strategical standpoint (Roblek et al. 2019; Pfohl, Yahsi, and Kuznaz 2015; Alcácer and Cruz-Machado 2019). Thereby, managers are able to get a broader overview about SC operations (Graham C. Stevens and Johnson 2016).

Industry 4.0 and digital SCM encompass numerous technologies (B. Nicoletti 2017) which offer transformation power across industries and sectors, such as Internet of Things (IoT), Big

Data, Data Analytics, Artificial Intelligence (AI), Robotics and Blockchain (B. Nicoletti 2020; Lu 2017).

SCM involves many activities and actors across divisions and organizations, hence, is a complex topic that is a playground for research (Ketchen and Giunipero 2004). SCM has been researched by various disciplines, including procurement, logistics, warehouse-, operations- and information management (Chopra 2019; Blanchard 2021; Dweekat and Al-Aomar 2018; Mrozek et al. 2020).

Although researchers predict the transition to a digital world and project the transition to digital SCM in the upcoming years, there are still many disciplines within digital SCM that have received relatively little attention (Baryannis, Validi, et al., 2019; Cavalcante et al., 2019; Jahani et al., 2021; Kusiak, 2017; B. G. Son et al., 2021; Trung et al., 2020; Dadouchi and Agard 2021). The following study on digital technologies in SCM covers four different parts that explore research and implementation gaps within said area, thereby making a meaningful contribution to existing research papers. Therefore, the topic of digital SCM was instinctively researched before the four sub-topics were chosen. Those topics analyze AI in procurement (chapter 5), application of RSs in SCM (chapter 6), parcel Although researchers predict the transition to a digital world and project the transition to digital SCM in the upcoming years, there are still many disciplines within digital SCM that have received relatively little attention (Baryannis, Validi, et al., 2019; Cavalcante et al., 2019; Jahani et al., 2021; Kusiak, 2017; B. G. Son et al., 2021; Trung et al., 2020; Dadouchi and Agard 2021). The following study on digital technologies in SCM covers four different parts that explore research and implementation gaps within said area, thereby making a meaningful contribution to existing research papers. Therefore, the topic of digital SCM was instinctively researched before the four sub-topics were chosen. Those topics analyze AI in procurement (chapter 5), application of RSs in SCM

(chapter 6), parcel lockers for sustainable city mobility (chapter 7), and vertical integration as an enabler for quick commerce (chapter 8).

As globalization created a competitive environment with increasing customer demand, the main target of any business is to satisfy customers (Deloitte, 2017; Gartner, 2021). To satisfy customers, products need to be delivered in optimal time as well as in optimal quality, quantity, and price (Prakash and Rakesh 2018). This fact, along with the outbreak of the global COVID-19 pandemic in early 2020, causing major SC disruptions and "putting global supply chain networks into the spotlight," is forcing SCs to make rapid changes (Chowdhury et al. 2021). Gartner (2021) is therefore urging firms to build more resilient and agile SCs, adapting rapidly and cost-effective in uncertain market environments (Modgil et al., 2021; Carvalho et al., 2012). The application of AI was identified to strengthen SCs as it encompasses features of machine learning (ML), Deep Learning and Big Data (Gupta et al., 2021). While an IBM report highlights the relevance of a more intelligent SC already ten years ago (Butner 2010), only few studies have tried to present an extensive overview about digital SCM in literature (Zekhnini et al. 2021; Belhadi et al. 2020; Wu et al. 2016; Büyüközkan and Göçer 2018). This justifies the motivation of this research to highlight application areas of AI in SCM as follows.

Procurement and strategic sourcing form the backbone of a SC, ensuring better control of resources, cost optimization and efficient supplier management (R. van Hoek et al. 2020). As such, the case of AI in procurement has been selected and is presented in section 4.

Improving overall SC efficiency requires firms to advance their performance, agility, and responsiveness (L. S. Chen et al. 2008). As a sub-discipline of AI, recommender systems (RSs) are designed to facilitate, influence, and predict buying decisions and customer behavior (Bobadilla et al. 2013). When applied in a SCM context, RSs create new opportunities for firms to optimize and streamline processes, improving overall SC agility. Section 5 illustrates the power of RSs in agile SCM.

The impact of e-commerce on wholesale, retail, and distribution, as well as the merger of offline and online worlds, and the increasing prevalence of out-home delivery alternatives represent challenges for many firms in the future. Tomorrow's customers will not wait, but rather expect to order and receive a product as quickly and convenient as possible. This poses major challenges for companies (Farahani, Meier, and Wilke 2015). To address this issue, section 6 investigates the opportunities of parcel lockers to improve sustainable city mobility.

Lastly, this report analyses the business model of one specific e-commerce niche, that is quick commerce companies in the grocery sector. Their business model depends on vertically integrating the complete SC to leverage the gathered data, leading to efficiencies that may disrupt the traditional grocery market. Yet, it requires further investigation of whether those firms can provide an economically sustainable value proposition. Therefore, section 7 explores if and how this business model will evolve and what implications it may have for the future of grocery shopping.

2 Work Project Structure

This paper is divided into ten consecutive sections. After an introductory overview of the research background and significance of the study, a comprehensive literature review discusses the concept of SCM and digital SCM. The subsequent chapters examine the impact of ETs on SCM and discuss both benefits and drawbacks of digital SCM for firms. Next, agile SCM, as one of today’s most important SC principles, is covered. Before introducing the chosen research methods for this study, the concepts of vertical and horizontal integration are introduced.

Sections four to seven discover different strategic and operative approaches to ET implementation in SCM, ranging from AI in procurement, RSs in agile SCM, over the implications of intelligent parcel lockers for sustainable city mobility to vertical integration as enabler for quick commerce. Each of those sections is structured similarly, commencing with a dedicated literature review and details about the selected research method. Then, the respective findings are presented, subsequently interpreted, and compared with existing literature as part of an in-depth discussion.

Finally, the research concludes with presenting overarching findings and highlighting practical recommendations and implications for future research.

3 Literature, Theoretical Background and Definitions

The following chapter presents a comprehensive overview of the current literature on digital SCM. First, a definition and the evolution of SCM explains the complexity of the SCM concept, followed by an overview about digital SCM together with its components. After elaborating the benefits and challenges for organizations with digital SCs, the concept of agile SCM, including its drivers and value proposition is introduced. Vertical and horizontal integration conclude the chapter.

Although this research presents different SC components and ETs to better illustrate relationships and explain knowledge gaps, some parts of the SC are covered in more detail than others. As such, this paper particularly examines the topics of purchasing, transportation, distribution, AI, ML, and agile SCM in more detail.

3.1 Supply Chain Management

Literature does not present a universally accepted definition of SCM (du Toit and Vlok 2014). All definitions refer to core principles, even if they differ in their level of detail and scope (Ibid.). Within a SC, all activities from raw material to end products are captured (Wisner, Tan, and Leong 2001). Thus, SCM describes "a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements" (Simchi-Levi, Kaminsky, and Simchi-Levi 2000). Activities, such as purchasing, transportation, manufacturing, materials handling, inventory, and distribution are components of SCM (Stock, Boyer, and Harmon 2010). However, the SC concept has gone through tremendous changes within the past 30 years (Knut and Rexhausen 2017).

SCM moving from the second Industrial Revolution towards Industry 4.0. The concept of SCM marked its beginning by the consultants Oliver and Webber's introduction in early 1980 (Oliver and Webber 1982). However, already back in 1911, Frederik Taylor (Taylor 1911) recognized the need for a scientific approach to manufacturing. Taylor, the father of Scientific Management, underlines in his practices a wide array of management practices, including assembly line production, tasks specialization and production quotas (Giannantonio and Hurley 2011). Even Henry Ford hit on Taylor's assumptions (Hounshell 1988) when he discussed origins, principles, and effects of mass productions on organizations back in 1926 (Ford 1926). Thus, the second industrial revolution which started in the first two decades of the 20th century introduced mass production (Davis 2016). With the introduction of steamships and the shipment of raw cottons from the US to England, global supply networks were introduced (Raman 2018). Moving to the third industrial revolution, from 1950 on, the importance of distribution and logistics increased (Habib 2009) and digital communication systems enabled to generate, process, and share information (Raman 2018). Additionally, this era was systematized of the conception of materials requirement planning (MRP) in 1960, focusing on inventory controls (Orlicky 1975). MRP further evolved which caused the emergence of enterprise resource planning (ERP) and thereby, greater visibility over the entire enterprise was created (Hayes and Wheelwright 1984). The total quality management practice which focused on improving quality and flows through inventory reductions and supplier involvements followed (Womack, Jones, and Roos 1990).

By 1990, the term SCM was fully introduced by a state-of-the-art article in SCM which addressed the need of managing strategical, tactical, and operational SC levels (G. C. Stevens

1989). At that time, organizations already started to consider creating agile SCs to react to changing demands as the awareness of end customers requiring levels of choice and differentiation increased (M. Christopher 2000). Through deficient information sharing about market demand, the "bullwhip" effect emerged and led to variations along the SC (Lee, Padmanabhan, and Whang 1997). Thanks to technology, information flows were able to get improved (Ibid.). However, in the twenty-first century, organizational challenges were exacerbated due to increasingly complex networks and issues caused by information distortion. Additionally, pressure on firms to become more transparent in order to prove green and sustainable SCs evolved (Srivastava 2007).

Next, the fourth Industrial Revolution caused a fundamental change in the way of living and working (Raman 2018) and thereby, to SC 4.0 which applies Industry 4.0 innovations (Knut 2016). The following section describes precisely digital SCM and Industry 4.0 innovations.

3.2 Digital Supply Chain Management

Companies have been greatly affected by digitalization and ETs, heralding a new era of complex and diverse environments and a competitive business marketplace (Ageron, Bentahar, and Gunasekaran 2020). By moving from traditional towards digital SC processes, firms are able to create both competitive advantages and sustainable values as a base for organizational changes (Attaran 2020). In general, digital SCM can be described as the development of information systems and the adoption of innovative technologies enhancing SC integration and agility, hence improving customer service and sustainable business performance (Ageron, Bentahar, and Gunasekaran 2020). Digital SCs use ETs, such as Big Data, Blockchain, IoT, or AI, to build a customer-centric strategy, while leveraging opportunities to reduce intra- and interorganizational costs (Ibid.).

Moreover, increasing variability, uncertainty, complexity, and dynamicity of markets may hamper a firm's SC monitoring and controlling processes (Hopp 2011; Dweekat and Al-

Aomar 2018). Thus, integrating information and communication technologies allows companies to leverage and match the intelligence of physical objects with internal and external data based on automation and connectivity throughout the SC (Ibid.). Further, it allows firms to access computed information and process results independently from time and location to make evaluated and business-driven decisions (Mrozek et al. 2020).

3.3 Components of Digital SCM

3.3.1 Procurement

Theoretical Background. The research in the field of purchasing is increasing, it shows growing importance and is gaining significant academic interest (Bentahar 2018; Harland et al. 2006). However, the field lacks theoretical robustness (Chicksand et al. 2012; Spina et al. 2016).

Generally, the task of procurement is to acquire goods and services which are critical to an organization (Karttunen 2018). Core tasks of purchasing are the determination of requirements, market research, analysis and evaluation of make-or-buy decisions, contract agreement, order processing, supplier management, strategic purchasing management, and controlling (Kaufmann 2002). Thus, processes in procurement are complex and include different strategic, tactical, or operational activities. The comprehensive end-to-end process is frequently referred to as procure-to-pay (P2P) or source-to-pay process which starts with requirements received from internal customers to final payment (B. Nicoletti 2017a). Already in 1996, purchasing was assigned an important role within the entire SC since its process links with every other department in an organization (Giunipero and Brand 1996). Additionally, procurement is known as an interface between internal and external partners as well as inner capacities and external accomplices. Thus, optimizing procurement processes may reduce costs and increase competitiveness which makes a performing procurement function increasingly important (Bals et al. 2019).

Moving to digital procurement. Recently, the traditional procurement process has gone through dramatic changes which were driven by new market conditions and an increase in variability and competition in the markets (Watuleke 2017). The evolution of procurement ranges from procurement 1.0 where the procurement function was to manually get the right product to the right time at the right place under right conditions (Ibid.). Procurement 2.0 indicated the development of integrated services in procurement (Glas, Andreas H., Kleemann 2017). Following, the third industrial revolution that was marked by the introduction of the computer, and thereby, completely new types of innovative technological solutions was introduced (Watuleke 2017). Thus, during procurement 3.0, several instinctive computer applications were developed to support procurement management (Ibid.).

One milestone was achieved by the development of the advanced software application ERP which increased in popularity since 1990 (Elragal and Haddara 2012). ERP systems enable better coordination with suppliers and integration of business processes and functions, as they improve the flow of information within and between functions (Kumar and van Hillegersberg 2000). Importantly, ERP systems are known to form the backbone for e-Procurement systems (Katuu 2020). E-procurement is the first step towards digitalization and supports the procurement process with electronic solutions (Watuleke 2017). It gives procurement operational and tactical support (Glas, Andreas H., Kleemann 2017) by covering strategic (eSourcing) and operational (eOrdering) processes (Weigel and Ruecker 2017). Over time and by developing technologies, procurement 4.0 has emerged with higher advantages through interconnected systems (Ibid.). In order to build a platform for digital procurement, electronic data interchange (EDI) as an IT process acts as an enabler by allowing information flows within and across organizations (Liu, Prajogo, and Oke 2016; Glas and Kleemann 2016)

With Procurement 4.0 and e-Procurement systems, operational processes can get mostly automated, and by applying Big Data Analytics, decision-making processes can be supported

(Glas and Kleemann 2016). Once organizations move digital, they have to fundamentally re-think operational processes (Adam, Glunz, and Kost 2018). Thereby, the role of buyers in procurement may change as some operational tasks get abolished in the future (Ibid..). Therefore, analytical tasks with higher IT and process knowledge are increasingly required in firms (Glas, Andreas H., Kleemann 2017). Lastly, the emergence of ETs and increased data availability enable managers to deal with uncertainties (Dubey, Gunasekaran, and Childe 2015).

3.3.2 Manufacturing

Manufacturing is the act of producing goods and describes the process of transforming raw materials into finished goods with the help of human labor, machines, tools, and chemical processing (Ghobakhloo 2018). Industry 4.0 concepts cause rapid evolvements of manufacturing techniques that can complement or replace traditional manufacturing processes (Gibson, Rosen, and Stucker 2010). Additionally, the transition towards digital manufacturing causes a "shift in the manufacturing logic towards an increasingly decentralized, self-regulating approach of value creation, enabled by concepts and technologies" (E. Hofmann and Rüsch 2017). Technological advancements related to manufacturing include "smart factories", "smart manufacturing", "additive manufacturing", "digital factory", "rapid prototyping" or "3D printing". Thus, new manufacturing techniques integrate cyber-physical systems enabling communication of physical resources via IoT (Ghobakhloo 2018; E. Hofmann and Rüsch 2017).

3.3.3 Warehousing

Warehouses are used to receive, store and ship goods to customers and manage inventory levels (ten Hompel et al. 2007). Further, they play a vital role in a firm's SC and are the bridge between supplier and end-customer (Ibid..). Since a large number of products is stored in warehouses, it is necessary to efficiently plan warehouse capacities, thus maximizing their utilization (Karasek 2013). Managing warehouses contain complex activities such as capacity planning, controlling, optimizing of inventories, and storing location assignment (Faber, de

Koster, and Smidts 2013). The introduction of automated warehouse management systems (WMS) ensures less organizational effort, increases efficiency, and reduces costs (Ramaa, Subramanya, and Rangaswamy 2012). In automated WMSs, devices can communicate their location and time of arrival to the warehouse, leading to real-time system optimizations by determining appropriate slots and routes for devices (Barreto, Amaral, and Pereira 2017).

3.3.4 Transportation

Transportation is a critical SC component and refers to the product movement from the beginning to the end of the SC (Chopra 2019). There are four major stakeholders in transportation processes (Ibid..). Shipper and carrier directly impact transportation, while transportation infrastructure owners and policy makers are indirectly related to the transportation process (Ibid.). The shipper owns and commands the product movement between different locations and selects the most suitable transportation mode (Blanchard, 2021). The carrier is responsible for the physical transportation process, hence directly impacting its effectiveness (Ibid..). In addition, transportation is a major source of emissions, accounting for a quarter of all carbon emissions in Europe (European Commission 2019). Since transportation speed is related to the level of carbon emissions, the amount of those emissions must be considered when selecting the appropriate transportation mode (Cachon and Terwiesch 2013).

Transportation is vital for SC success and competitiveness. ETs have led to improvements in transportation quality, costs, and speed (Ivanov, Tsipoulanidis, and Schönberger 2019). The use of real-time data, for instance, facilitate route optimization and allow maximizing fleet utilization (Ibid.).

3.3.5 Distribution

Distribution networks have been impacted significantly since the rise of ETs, creating increasing competitive pressure due to accelerated technological development. The distribution of goods and services increased in complexity by adding digital touchpoints into the customer journey of Business-to-Consumer (B2C) and Business-to-Business (B2B) transactions (Martin 2016). To cope with the generated data by online sales, physical stores must also implement data-driven strategies, often resulting in omnichannel approaches (Adivar et al., 2019). Moreover, Internet-based connectivity and transparency between supply and demand are increasingly eliminating the need for intermediaries, a process known as "disintermediation" (Gruchmann and Bischoff 2021). However, there is an opportunity for former intermediaries to move to an aggregator or platform strategy supported by expertise in a crowded market.

The direct-to-consumer trend is also driven by more agile and international logistics providers, which make it economically feasible to combine response speed with a lower cost of ownership. These developments may lead to a shift from a seller-centric to a buyer-centric market, where customer orientation becomes the core of the distribution strategy (Martin 2016). While pure online players emerge and sell directly to the consumer, traditional retailers converge their physical stores into an omnichannel approach, where all distribution routes are connected to increase customer satisfaction and realize efficiency potential. Omnichannel therefore has the potential to improve business metrics on the four dimensions of sustainability, efficiency, responsiveness, and flexibility (Adivar et al., 2019). Thus, the direct-to-consumer online business model has created great potential for improving the distribution processes of physical goods between supplier and customer, opening opportunities for third-party providers (3PL) such as DHL, FedEx, or UPS to fill this gap (Ibid.). Those 3PLs usually integrate operation, warehousing, and transportation services to meet customers' and suppliers' needs (Ibid.). By consolidating shipments from multiple suppliers, 3PLs can operate at economies of scale which, in most cases, cannot be achieved by a single supplier (Azizi and Hu 2020). As an exception of this concept, quick commerce will be discussed more detailed in chapter 7.

3.4 Enablers of Digital Supply Chain Management

The following section is going to present those ETs which are considered as crucial enablers in digital SCM. Firstly, the function of the respective technology is described, followed by some application areas within SCM.

3.4.1 Internet of Things

The core concept of IoT is to build a "network of physical objects that contain embedded technology communication and sense" (WEF 2015) that allow communication between objects over the Internet (Evtodieva et al. 2020). Thus, IoT describes smart devices and sensors connected to the Internet, collecting and sharing data for use and evaluation by many organizations (Fernandes 2018; Hermann, Pentek, and Otto 2016; Mittal et al. 2017; Müller, Kiel, and Voigt 2018; Chamekh et al. 2018). IoT infrastructure is based on different network types which allow communication between devices, such as PAN, LAN, WAN, and cloud (Ibid..). Appendix 1a describes each of the network types in detail.

Since connection plays a crucial role in SCM, experts believe in the transformational power of IoT in SCs (G. Nicoletti, von Rueden, and Andrews 2020). Through IoT, a large network of smart infrastructure to merge data, information, products, physical objects, and processes of a SC is established (Abdel-Basset, Manogaran, and Mohamed 2018). Within SCM, IoT is mostly used in manufacturing, warehousing, and transportation (Abdel-Basset, Manogaran, and Mohamed 2018). For instance, inventory costs, as well as the bullwhip effect across SCs, can be reduced through IoT (Ibid..).

3.4.2 Blockchain

The central innovation of the Blockchain architecture is its decentralized organized system, which enables trustworthy transactions between parties on a global level (Walport 2015). Blockchain is described as an electronic ledger (register) of digital records, events or transactions that are presented, authenticated, and managed in a condensed form known as a hash (digital security feature) over a distributed or shared network of participants using a group consensus protocol (Condos, Sorrell, and Donegan 2016). Accordingly, Blockchain generally represents a type of database and groups data into blocks. Each block is linked with a cryptographical signature to the next block (Walport 2015). Once established, a block cannot be changed or deleted, and instead, is verified and managed using automation and shared governance protocols (Christidis and Devetsikiotis 2016). As a peer-to-peer network, Blockchain implies that each participant maintains a replica of a shared ledger of digitally singed transactions (Y. Wang, Chen, and Zghari-Sales 2021).

From a SC perspective, transactions between organizations no longer occur bilaterally, for instance between a supplier and a manufacturer. Instead, blockchain decreases the complexity of bilateral communication by providing a single, shared, and secure ledger that records transactions as they occur (Y. Wang 2019). Within a firm's SC, Blockchain can improve SC visibility (Schmidt and Wagner 2019). Additionally, Blockchain enables process automation through smart contracts, improves process flows, increases SC security and responsiveness, and ensures traceability of flows and goods. This results in streamlined processes with shorter lead times, less redundancy, fewer delays, and ultimately a leaner SC (Y. Wang 2019).

3.4.3 Data Analytics

According to Souza (2014), analytics can be categorized into descriptive, predictive, and prescriptive analytics. Descriptive analytics describes the analysis and interpretation of historical data to gain a better understanding of changes in an organization (Thomas H. Davenport 2018; Souza 2014). Predictive analytics is used to predict future events by collecting past data and manipulating data sets with methods like regression analysis and exponential smoothing (Ibid..). Prescriptive Analytics, on the other hand, draws from descriptive and predictive analytics to a future model (Souza 2014). Further, the application of advanced statistics to any kind of stored electronic communication can define Big Data Analytics (McAfee and Brynjolfsson

2012). Generally, Big Data Analytics is known for managing, possessing, and analyzing data, and thereby, focusing on the 5V of data characteristics, volume, variety, veracity, and value, and is crucial for organizations (Fosso Wamba et al. 2015). The intention of Big Data Analytics is to identify behavioral patterns inside data, which may allow forecasting future behavior to some extent (White 2012). Critical supporters for Big Data Analytics are Data Analytics and Data Mining (Witten, Frank, and Hall 2016; T.H Davenport 2013). Data Mining and Process Mining are popular for decades (van der Aalst 2012; Cheng et al. 2013). Even though Process Mining is related to Data Mining (Hand, Mannila, and Smyth 2001), it is important to distinguish between both mining techniques. Process Mining is process-centric and by extracting knowledge from event logs in information systems, it aims to discover, monitor, and improve processes (van der Aalst et al. 2011). Techniques in Data Mining are mostly data-centric (Hand, Mannila, and Smyth 2001). Therefore, a closer look at the potential of analytics 4.0 is going to follow in the next paragraph.

3.4.4 Artificial Intelligence

A McKinsey report on AI highlighted that AI "is poised to unleash the next wave of digital disruption" and since early adopters have achieved higher profit margins, companies should prepare for digital transformation (Bughin et al. n.d.). Additionally, multiple authors (Sengupta 2013; Tirkolaee et al. 2021a; Chui, Francisco, and Manyika n.d.) highlight AI as a future key driver for the digital transformation in SCs. Since section five and six of the study focus on AI and ML, the following sub-chapters describe AI topics in more depth.

3.4.4.1 Background on Artificial Intelligence

By now, there is no universal definition for AI. However, Amazon defines AI as "the field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem-solving, and pattern recognition" (NRDSI 2019). AI can be divided into augmentation and automation. Augmented Intelligence has been developed to assist humans with their daily tasks (Raisch and Krakowski 2020). In automation, AI works fully autonomous without human's assistance (Raisch and Krakowski 2020). With the help of AI, valuable insights with fewer interventions and human errors can be analyzed and processed out of structured and unstructured data (Taulli 2020). The definition of Hanenlein and Kaplan (2019) captures an overlap between AI and Business Analytics by describing AI as "a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation". That overlap is also important in the context of this research paper and section 5.1.2 is going to analyze the overlap in procurement.

Lastly, it is crucial to understand that AI covers many technologies (Dejoux and Léon 2018). ML with its different types is the basis of most AI techniques and therefore, the following paragraph is describing each type in depth. Finally, Robotics Process Automation (RPA) as a form of AI based software tool is going to be described in the last paragraph more in depth.

3.4.4.2 Machine Learning

Machine learning (ML) represents a sub-discipline of AI that automatically identifies and extracts patterns between variables based on large data sets (Zhang 2020). Samuel (2000) defined ML as a "field of study that gives computers the ability to learn without being explicitly programmed". Using computational methods and mathematical models, ML algorithms are able to learn from experience and provide predictions or decisions without being explicitly programmed to do so (Mohri, Rostamizadeh, and Talwalkar 2018). The term "experience", as used here, refers to the historical data used to train a ML model, consisting of either digitized human-labeled training sets, data extracts obtained by IoT-devices, or other types of information collected through interaction with the environment (Alzubi, Nayyar, and Kumar 2018).

In the past, the extraction and interpretation of information from large amounts of data posed a challenge using traditional Data Analysis techniques (Attaran 2020). Unlike traditional methods for data analysis, ML models are capable of dealing with large, unstructured data coming from different sources and in different formats (Mohri, Rostamizadeh, and Talwalkar 2018).

Machine Learning Model Development. Regardless of the algorithm applied, a ML model generally consists of six components, where each component of the model shall perform a specific task (Alzubi, Nayyar, and Kumar 2018). First, all necessary data must be collected and pre-processed to fit the applied algorithm (Ibid..). Before selecting both ML model and model parameters, suitable features and algorithms are selected (Mohri, Rostamizadeh, and Talwalkar 2018). Then, the model is trained and evaluated based on performance parameters (Ibid..). An overview about the most common ML terms, as well as ML paradigms and ML model development can be found in appendix 1a.

3.4.4.3 Robotic Process Automation

The compound annual growth rate of about 33% of RPA's market size from 2021 to 2028 (Grand View Research 2021) illustrates the growing importance of understanding what RPA can be used for. RPA consists of software licenses, called bots, and is applied to redesign and optimize business processes by automating repetitive, mundane, and rule-based processes (P. Hofmann, Samp, and Urbach n.d.; Syed et al. 2020; Viale and Zouari 2020). It is essential to understand that RPA is not a physical robot, but instead a software-based solution that automates routine tasks and uses structured data (Lacity and Willcocks 2016). Structured data can be organized and stored in predefined depositories such as databases or spreadsheets. While unstructured data comes in various forms, it is not formatted to fit into databases. It can consist of PDF data, e-mails, images, and audio files (Taulli 2020). RPA 3.0 is the latest version of RPA (Baviskar et al. 2021).

However, before RPA, a first step towards digitalization was done by Optical Character Recognition (OCR), which can be utilized by transforming document contents into a digital format. "Omni-front OCR" was proposed as a technology processing text printed in almost any font in 2000 (Baviskar et al. 2021). Nowadays, OCR is offered via APIs and is capable to accurately recognize almost all characters and fonts. Application Programming Interchange (API) is a software tool that shares data content between software applications (Preibisch 2018). Nonetheless, RPA moves automation further in having a rule-based logic at the core of most automated processes with its software bot (Siderska 2020).

The evolution of RPA starts with RPA 1.0 which still needs human-computer communication. RPA 2.0, known as unassisted RPA, can automate tasks without human assistance. A human only needs to login into a system and activate the initiation of the process. Lastly, RPA 3.0, known as autonomous RPA or as an AI-enabler, refers to cognitive RPA that can segregate and automatically respond to several e-mails (Baviskar et al. 2021). Thus, by leveraging AI, a RPA system is able to transfer data from multiple input sources, such as e-mails, spreadsheets or PDFs to CRM or ERP systems (Lacity and Willcocks 2016).

Therefore, bots' ability to log into IT systems and start back-office applications, followed by extracting, processing, and inserting semi-structured or structured data, makes them perform calculations and send out e-mails automatically (Syed et al. 2020; F. Huang and Vasarhelyi 2019). However, once implementing RPA, it is fundamental to understand processes, systems, and workflows (Ibid.). Therefore, the usage of a flowchart is common since it breaks down all process specifications and characteristics (Ibid.). Thus, RPA rather sits on top of information technologies than being part of an information technology infrastructure (IRPAI 2015). How and where RPA and RPA 3.0 applications can create new business value, is shown in section 5.1.2.

3.4.5 Advantages of Digital Supply Chain Management

Several issues in today's fierce competition, such as shrinking resources, rising cost, shorter product life cycles, customer's changing preference with demand variability, technology obsoleteness and market globalization are causing threats to many companies (Gumte et al.

2021). This leads many firms to invest in ETs for SC optimization (Ibid..). The following chapter illustrates how organizations can benefit from implementing ETs within their SC.

Sourcing. Companies adopting their sourcing processes quickly can benefit from cost, resilience, and growth potential when leveraging AI solutions (Aggarwal, Dave, and Davè 2019). According to a recent McKinsey study, new ML tools can reduce the time to identify a new supplier by 90% (Baptista et al. 2021). AI especially supports the processes of supplier selection, coordination, and segmentation (Aggarwal, Dave, and Davè 2019). Chapter 5 explores the benefits of integrating AI into procurement and purchasing processes in more detail.

Demand and sales estimation. AI can help companies to better manage demand fluctuations with increasing transparency and connectivity throughout the SC (Bunter 2017). By collecting IoT-based real-time data and information from different stakeholders along the SC, companies can implement AI solutions analyzing demand fluctuations and customer behavior (Ibid..). Therefore, organizations are able to exploit competitive advantages within the market (Ibid..).

Manufacturing. Data generated by IoT devices allows companies to analyze machine performance and process efficiencies in real-time (Zhong et al. 2017). Thereby, IoT enables process transparency in manufacturing (B. hu Li et al. 2017). Further, several studies highlight the benefits of AI integration into manufacturing and production processes of organizations (Tirkolaee et al. 2021b). Companies can apply AI technologies to SC data pools to predict and manage demand volatility, supply constraints and production scheduling (Bunter 2017). When used in production processes, AI can complement human interaction by allocating resources, assigning employees, and planning processes (Ibid..).

Warehousing and inventory management. ETs are widely used in warehousing and inventory management (NRDSI 2019). AI in warehousing and inventory management enables companies to connect supply, demand, storage, and transportation of materials with high

efficiency, leading to long-term low-cost advantages (Dadouchi and Agard 2021). For instance, ML in the context of warehousing and inventory management enables more precise demand forecasting activities through leveraging all kinds of data on inventory and customer behavior (NRDSI 2019). Further, the reduction of waste by optimizing material retrieving, the early detection of defective material for shipping and therefore the minimization of shipment errors can enable both cost savings and the development of lean processes in warehousing.
(NRDSI 2019).

Transportation and distribution. Additionally, the deployment of AI and IoT for more effective routing, consolidation, cross-docking and redirecting of shipments can optimize transportation and distribution planning (NRDSI 2019). It further increases trackability and traceability (Fragkiadakis, Moysiadis, and Zotos 2019).

Supply chain security. Within SCM, Blockchain can provide comprehensive security to its processes (Al-Farsi, Rathore, and Bakiras 2021). The technology provides data integrity and ensures the protection of information exchanged between business partners and customers, protecting data from tampering attacks (Xu et al. 2021).

Supply chain risk prediction. The early identification of SC risks is essential for the timely introduction of countermeasures to avoid SC disruptions (Schroeder and Lodemann 2021). Here, ML can support a business in predicting potential causes of process disruptions and analyzing past interruptions to minimize financial losses and process failures throughout the SC in the future (Baryannis, Dani, and Antoniou 2019).

Sustainable supply chain development. Lastly, ETs can support companies in identifying and executing sustainability improvements within the SC (Geissdoerfer et al., 2018). Improvement areas can range from equipment planning, or operational processes, to CO2 emissions, or fuel consumption (Genovese et al., 2017). Thus, digital technologies' ability to reduce material flows and lead times may help in achieving sustainability goals (Ghisellini, Cialani, and Ulgiati 2016).

3.4.6 Challenges of Digital Supply Chain Management

When transitioning into digital SCM, firms may have to overcome potential challenges to leverage the full potential of digital SCs. Those challenges can be assigned to the following areas, including stakeholder resistance, the development of a trusting environment and technology strategy, cost, and resource management, as well as cyber security (Bhatnagar et al. 2018; Geisel 2018; Gesing, Peterson, and Michelsen 2018; Manyika et al. 2017; NRDSI 2019).

Stakeholder resistance. Resistance to a new technology often results from stakeholders not believing in the benefits of a technology or fearing the loss of control with the introduction of a new technology (NRDSI 2019). Further, many employees fear the loss of their position, as many studies report the replacement of human labor by digital technologies (Geisel 2018). It is indeed possible for ETs to eliminate certain positions, decrease the visibility of others, and yet to generate greater value for the company as a whole (NRDSI 2019). A 2017 McKinsey report shows that automation leads to big shifts in the world of work, as AI and Robotics change or replace jobs, while others are created (Manyika et al. 2017). However, most stakeholders are not aware of the fact that technological change continuously generates new types of employment, and that ETs may create more new workplaces than it will eliminate (NRDSI 2019). Manyika et al. (2017) state that “millions of people worldwide may need to switch occupations and upgrade skills”.

Development of a trusting environment and technology strategy. As the introduction of an ET requires a change in behavior, change management processes, the establishment of a comprehensive technology strategy, as well as sufficient leadership support are essential to build the right environment for adaption (NRDSI 2019). A joint study by IBM and DHL shows that when introducing AI to a business, it is important to build trust within the organization and develop a deep understanding of organizational attitudes towards ETs (Gesing, Peterson, and Michelsen 2018). Thus, organizations and leaders must efficiently communicate and demonstrate that new technologies will rather augment than eliminate jobs to offer assurance and guidance to employees (Gesing, Peterson, and Michelsen 2018).

Cost and resource management. The transition to digital SCM requires financial, physical, and human resources which may not be sufficiently available to certain organizations (Geisel 2018). A large skill gap in Data Science and information management might hinder the adoption of AI in businesses and challenges especially smaller businesses in acquiring skilled talent (NRDSI 2019). Further, as data volume grows and processes become more complex, hardware requirements for data acquisition, storage, and processing change (NRDSI 2019). Companies must therefore support those changes by providing both financial and human resources for successful integration of new technologies (Gesing, Peterson, and Michelsen 2018).

Cyber security. Adopting ETs can help companies to reduce cyber risks, while also exposing them to new forms of corporate cyber fraud (NRDSI 2019). The malicious use of AI to sabotage the SC is challenging for firms given the dual-use nature of AI and the fact that many of the malicious uses of AI involve legitimate uses as well (NRDSI 2019). Bhatnagar et al. (2018) report that with AI capabilities becoming more powerful and widespread, the increasing use of AI systems is leading to growing threats for organizations. According to the researchers, the growing use of AI may lead to more effective and specifically targeted cyber-attacks, which are difficult to attribute and are likely to exploit vulnerabilities of AI systems (Bhatnagar et al. 2018).

3.5 Agile Supply Chain Management

Agility can be considered one of the most challenging aspects of today’s SCM (Shashi et al. 2020; Ladeira et al. 2021). The development of an agile SC strategy has become critical for businesses to efficiently manage their supply network, develop flexible capabilities to meet changing customer demands and ultimately gaining competitive advantage against other market participants (Dadouchi and Agard 2021). The concept of agile SCs emerged in the early 2000s when van Hoek et al. (2001) addressed SC agility as a response to increasingly volatile markets and globalization. As unexpected market changes and uncertainty have become more frequent, agility emerged to a key business principle enabling firms to identify and handle external disruptions effectively (R. I. van Hoek, Harrison, and Christopher 2001). Ismail & Sharifi (2006) refer to SC agility as “the ability of the supply chain as a whole and its partners to rapidly align the network and its operations to the dynamic and turbulent requirements of the demand network”. Christopher (2000) states that agility describes “a business-wide capability that embraces organizational structures, information systems, logistics processes, and, in particular, mindsets”.

3.5.1 Drivers of Agile Supply Chain Management

To leverage a firm’s full potential of SC agility, researchers identified multiple key characteristics for agile SCs. Shashi et al. (2020) propose cost, efficiency, and speed as the three fundamental drivers of SC agility, with flexibility and responsiveness representing key enablers. Based on those drivers, Christopher (2000) suggests a framework containing four characteristics for agile SCs. The guideline implies that a company's path to agility involves digitization processes, such as EDI, IoT, or electronic points of sale, and that an agile SCM strategy is inherently digitally supported (Ibid.). Following this approach, the four pillars for an agile SCM strategy consist of market sensitivity, virtuality, connectivity, and process integration.

Market sensitivity. According to Christopher (2000), an agile SC is market sensitive, therefore being able to identify and quickly respond to demand in real-time. While many firms rely on past trends for demand planning, agile SCs use real-time sales information and customer feedback to forecast future demand (R. I. van Hoek, Harrison, and Christopher 2001). This implies that the success of a SC depends significantly on a firm’s ability to understand customer behavior and derive new trends accordingly (Dhaliwal and Arora 2021). Due to the current increase in large-scale, real-time, and multi-directional information flows, companies can leverage Big Data Analytics to improve demand management and market sensitivity by better understanding and instantly reacting to market signals (Martin Christopher 2000). This can help companies to quickly adjust customer strategies and offerings, such as reordering individual product assortments based on predicted customer behavior (Cifone et al. 2021).

Virtuality. The adoption of information technologies to share data between different SC stakeholders is essential to forecast and satisfy market demand (Martin Christopher 2000). Therefore, collaboration between the different SC partners lays the foundation to ensure that all SC stakeholders can focus on their core competencies while having all relevant information available for optimal decision making (Sheng and Saide 2021). While traditional approaches to SC planning are based on historic data to determine optimal stock levels and their geographical arrangement, this principle becomes obsolete once demand is visible and plannable through the exchange of shared information (Shashi et al. 2020). The use of Internet- and cloud-based information storage and interchange has thus enabled SC stakeholders to act upon the same, real-time data to fully leverage and integrate their SC solutions, contributing to end-to-end visibility throughout the SC network (Sheng and Saide 2021).

Connectivity. Fully integrated SCs operate on an alliance of stakeholders working together as a network of partners, sharing information, and collectively achieving success across the SC (Martin Christopher 2000). This approach implies the equally distributed ownership of the SC and its performance (Ibid.). Given that the traditional understanding of individual companies competing as separate entities rather than as entire SCs has become outdated, companies are now competing within the SC network (Shashi et al. 2020). Therein, businesses that can better structure, coordinate and manage relationships with their partners in a network will benefit by establishing stronger, closer, and more flexible relationships with their end customers (Shcherbakov and Silkina 2021).

Process integration. Information sharing between SC partners can only be fully exploited through process integration (Martin Christopher 2000). Sashi et al. (2020) state collaboration, information sharing and joint goals as the base of process integration. As today's SC partners focus more on leveraging individual core competencies and outsourcing remaining activities, collaboration becomes one of the most important principles in agile SCM (Sheng and Saide 2021). Further, digitization processes allow more efficient and diversified information flows, improving both connectivity and process integration in agile SCs (Ladeira et al. 2021). Process integration therefore leads to a greater number of collaborating network partners, transparency of information, resilient network structures, the development of innovations, co-creation, and joint decision-making and strategy determination (Ibid.).

3.5.2 Benefits of Agile Supply Chain Management

Agility has made SCs more information- and customer-centric and evolved to an inevitable principle that must be integrated into the corporate strategy, requiring strategic commitment and continuous management support (Dadouchi and Agard 2021). Further, research shows that leveraging ETs, such as IoT, AI, and Blockchain within agile SCs can be used to both understand and predict consumer behavior more precisely, but also to influence demand towards particular products, as explored in section 6 (Dhaliwal and Arora 2021).

3.6 Vertical and Horizontal Integration in Supply Chain Management

Due to the growing complexity of SCs, the degree of SC vulnerability tends to increase, the more interdependencies and external factors influence companies' SC processes (Tang 2006). While prices may rise abruptly, products or raw materials may be unavailable, shipping and transportation may be congested, or competitors may be vying for customers (Telukdarie et al. 2018). Horizontal or vertical integration can provide firms with a better organization and overview of processes to meet increasing customer expectations (M. C. Huang, Yen, and Liu 2014). However, companies should carefully consider the benefits and drawbacks of both approaches, depending on the firm's business goals and priorities (Ibid.). The following sub-chapters provide an overview about both vertical and horizontal integration to lay a foundation for section 7, which focuses on vertical integration as an enabler for quick commerce.

3.6.1 Vertical Integration

Vertical integration describes the strategy of a single company owning and controlling at least two or more stages of the SC, such as manufacturing, warehousing, or distribution (Ursino 2015). Therefore, a company must decide whether to provide certain goods or services internally or to source them from external providers instead (*The Palgrave Encyclopedia of Strategic Management* 2016). With vertical integration, companies combine multiple stages of the SC from input to end user under a common, centralized ownership to control each step within a single organization (Ibid.). Typically, the reason for vertical integration of companies is the lack of intermediate markets to support and link SC activities (Otto and Kotzab 2003). Thus, management actions and commands within an organization are leveraged to accomplish the required coordination and integration of assets within the SC (Ibid.).

Benefits of vertical integration include the avoidance of contractual difficulties through lower transactional costs, the elimination of skill deficits, and the enhancement of information efficiency (X. Liu 2016). In addition, a vertically integrated structure usually provides better access to resources, the ability to precisely coordinate integrated SC processes, and the opportunity to source goods or services without paying additional margins to intermediaries (Ibid.). To fully exploit the benefits of vertically integrated SCs, it is essential for firms to integrate ETs into their SC processes (W. Li and Chen 2020). As confidentiality may not be a major problem for those firms, technologies, such as IoT or AI, enable transparency and information sharing, which increases connectivity and allows companies to derive meaningful insights from gathered data (X. Liu 2016).

However, vertically integrated SCs may also have fewer opportunities for cost reductions in the event of an economic downturn or following radical technological changes (Zhou and Wan 2017). As integrated operations often disconnect from the market, a company may further face the risk of losing access to superior goods or services by relying on its internal sources (Ursino 2015).

3.6.2 Horizontal Integration

Horizontal integration of the SC describes the strategy of one company aiming to dominate or control the main part of a SC stage to realize strategic advantages (Christensen et al. 2019). Such an integration typically involves M&A activities or organic growth, by offering a larger portfolio of products and services on the same level of the SC (Ibid.). For instance, one company may carry out horizontal integration by acquiring and implementing a competitor into their logistics system, smoothing out competition for their convenience (Hall, Algiers, and Levitt 2018).

This type of merger potentially helps a company gaining more customers and provides greater control over price and supply (Hingley et al. 2011). Further, it supports a firm’s ability to increase its service level and reduce waste from over- or underproduction (Nagurney 2009). In addition, horizontal integration allows companies to decrease costs by sharing resources and to gain access to new products provided by competitors (Mason, Lalwani, and Boughton 2007).

Nevertheless, companies may face multiple challenges when it comes to horizontal integration (M. C. Huang, Yen, and Liu 2014). Different operating systems and infrastructures complicate collaboration and the exchange of information about SC processes (Hingley et al. 2011). This may lead to decreased flexibility as processes become difficult to control (Telukdarie et al. 2018). Further, due to missing data integrity, companies could miss important opportunities to improve efficiencies and leverage synergies across the SC (Hall, Algiers, and Levitt 2018).

4 Methodology

The following chapter will provide the reasoning behind the empirical research approach and method. To ensure an understanding of the scientific foundation of the paper, this section will explain the sampling and design of the research tools as well as the method of execution and analysis.

4.1 Research Approach and Method

This paper uses a qualitative research approach. Apart from the evaluation of secondary data, this study makes use of expert interviews for primary information. Gathering knowledge from different sources including secondary data and expert interviews deepen the understanding of the emergence of technologies in SC. Further, it provides a deeper understanding of the research topic due to its flexibility and ability to adapt interaction between the researcher and study participants (Bryman, 2012).

The paper illustrates four subtopics of digital SCM, which offer a comprehensive foundation to the underlying research questions (RQs). These were examined in more detail using semi-structured expert interviews.

4.2 Semi-structured Expert Interviews

"Experts are seen as crystallization points for practical insider knowledge" and, therefore, they can provide relevant and in-depth knowledge regarding the SCM and ETs (Bogner, Littig, and Menz 2014). In order to gain better insights into SCM and ETs, semi-structured interviews were conducted with industry experts to ensure a non-limiting interview process and to be able to adapt to the flow of the conversation as well as to topics that arise during the interview (Saunders, Lewis, and Thornhill 2009). For the selection of experts, this research uses non-probability sampling, where every interview participant is chosen by the researcher (Ibid.). This type of sampling ensures that the interview participants meet certain requirements that provide valuable first insights rather than producing generalizable results (Bryman and Cramer 2012).

The main topics covered by the interview guide are based on concepts and theories that emerge from the review of relevant studies in the research area. The interview guide with predetermined questions offers a focused structure for the conversation during the interview. However, to ensure a non-limiting interview process, the interviewer was able to adjust the questions depending on the conversation. Still, all predetermined questions will be answered during every interview, using a similar wording to ensure a level of standardization which allows the researcher to compare different interviews and therefore increases the reliability of the study (Bryman and Cramer 2012). In total, 31 semi-structured interviews were conducted.

4.3 Design of Research Tool

Prior to conducting expert interviews, interview-guides based on knowledge and main topics that emerged from the secondary research analysis were created. For the use in this paper, expert interviews were abbreviated with the character "E" followed by the number of the interviewee.

5 The Case of Parcel Lockers as a Solution for Improving Sustainable City Mobility

5.1 Literature Review

This study aims to understand how a combined solution of parcel lockers and night-time deliveries could be considered as a good solution. Individually, both topics have already been examined in different studies, however, jointly, there is still a lack of information. This study aims to close the above-mentioned gap, while answering the RQ: How night-time delivery combined with parcel lockers can be considered as a solution for Improving City Sustainable Mobility?

5.1.1 The Unparalleled E-commerce Growth

E-commerce is the process of buying and selling products or services via the internet (Bloomenthal 2021). Globally, its popularity has risen rapidly in the last few years while intensified by COVID-19 (Bhatti et al. 2020). Data provides evidence that 82% of all consumers have shopped online within three months and forecasts a 17% annual growth (WEF 2020).

Nonetheless, e-commerce has a drawback in that it contributes to heavy traffic, congestion, and environmental issues in urban areas (Mitrea et al. 2020; S. Iwan, Kijewska, and Lemke 2016; Chaberek 2021). This is due to an increase in the number of delivery vehicles, leading to higher emissions, and double parking (WEF 2020). If, on the one hand, it increases the demand for carriers to reach geographically dispersed consumers (Chaberek 2021), on the other hand, it reduces the need for individual customers to visit the stores, resulting in a 32% drop of the traffic (WEF 2020). However, according to a study based on the top 100 cities globally, delivery vans will grow by 36% by 2030 if nothing is done (Ibid.). Hence, a 32% increase in emissions and a 21% increase in congestion (equal to 11 minutes per passenger/day) are projected (Ibid.).

Influenced by diverse factors such as urbanization, availability of online products, an increased number of e-buyers, technology, and delivery methods, the demand for last-mile transport has never been greater in terms of parcel deliveries and returns (WEF 2020; Ferrucci and Bock 2014; Vakulenko, Hellström, and Hjort 2018). Customers expect to access them with the most convenient, and fastest delivery method, both in terms of time and location (Pronello, Camusso, and Valentina 2017). Thus, it has increased the difficulty for companies to deliver within the customers' preferred time windows (Grabenschweiger et al., 2021). Hence, innovative last-mile solutions were required (Ducret 2014; Morganti, Dablanc, and Fortin 2014). Collection-and-Delivery points (CDP) are a solution to effectively improve the last-mile delivery system while simultaneously promoting sustainability (Mitrea et al. 2020; M. Kiba-Janiak et al. 2021). This solution offers consumers an out-of-home self-collection service, which can be in an attended - service points - or unattended – parcel lockers (PLs) - (Mitrea et al. 2020). In fact, these solutions are preferred by many consumers (Tsai and Tiwasing 2021). Thus, both parties (consumers and logistics operators) avoid missed deliveries.

5.1.2 Intelligent, open Parcel Lockers: definition and different stakeholders' perspectives

Intelligent PLs are among the most discussed solutions in the last-mile for B2C. Intelligent PLs, or only PLs (Vakulenko et al., 2018), are defined as a shared self-service pick-up device for online purchases (Mostakim, R Sarkar, and Anowar Hossain 2019). PLs are based on IoT technology to identify, temporarily store, monitor, and manage their items while automatically sending a message to the user with the pick-up address and the verification code (J. Grabenschweiger et al. 2021; Behnke 2019) (Illustrative example in appendix 1a).

PLs are highly valuable for end consumers due to their advantages of accessibility, both in terms of time and location preference (Vakulenko, Hellström, and Hjort 2018). They are regularly located in areas included in the citizens daily routines with an extended schedule. Some examples are supermarkets, train stations, shopping-, business centers, universities, centers, pedestrian areas in the city center with high amounts of traffic or near apartments blocks. Thus, they are accessible by most means of transportation. In this way, flexibility, security, and convenience are guaranteed (Mostakim, R Sarkar, and Anowar Hossain 2019; C. F. Chen, White, and Hsieh 2020; Tsai and Tiwasing 2021; Chaberek 2021; Behnke 2019; Lachapelle et al. 2018; Prandtstetter et al. 2021). Moreover, the study made by Vakulenko et al. (2018) demonstrated that PLs are seen as a high-speed service for costumers since there is an elimination of queues due to no additional services or items being cross-sold, and parcels arrive faster to a PL. All in all, most of the participants of the mentioned and other recent studies confirm their satisfaction with such technology (Lemke, Iwan, and Korczak 2016; Stanisław Iwan, Kijewska, and Lemke 2016; Crocco et al. 2013; Behnke 2019). Moreover, in some cases, PLs were a driver of e-commerce. For example, a study led in Australia (2014) stated that 41% of consumers confirmed being more likely to increase online buying after experiencing a 24/7 service (Lachapelle et al. 2018).

Furthermore, with COVID-19 PLs has massively increased in interest for e-buyers due to its contactless nature (Chaberek 2021; Prandtstetter et al. 2021). However, from the customers perspective, the lockers are only beneficial if they foresee not being at home at the scheduled delivery time (Behnke 2019). Moreover, the final leg of the journey being made by the customer can be, to a certain extent, a weakness. (Torrentellé, Tsamboulas D., and Moraiti P. n.d.).

For the carriers, PLs are likewise advantageous. It lowers its costs, and the packages are distributed faster (Morganti et al. 2014). This is factual, as by agglomerating different parcels in one location, the driver decreases the length of the trip, and consequently, it may reduce the number of vans in the streets (Lin et al. 2019; Refaningati et al. 2020; Lachapelle et al. 2018). Additionally, by depositing the parcels in a locker, there will be no issues of missed delivery due to the recipients' absence (Tsai and Tiwasing 2021; Behnke 2019). This said, the travelled distance is reduced together with the associated energy consumption, traffic congestion, and greenhouse emissions of any delivery (S. Iwan, Kijewska, and Lemke 2016; Maja Kiba-Janiak et al. 2021; Perboli et al. 2018; Yuen et al. 2019). Hence, to take full advantage of PL benefits, the following two criteria must be combined (Behnke 2019). First, the location of the lockers should be carefully thought of, to be "en route" for the consumers (Prandtstetter et al. 2021). Second, the locations need to be strategically chosen, to result in the areas with the most traffic of parcels. To illustrate, the PLs company – InPost – can deliver to a PL 600 parcels in one day with a 70km journey, compared to 60 packages delivered with a journey of 150km in traditional delivery systems - e.g., home delivery - (Stanisław Iwan, Kijewska, and Lemke 2016).

From the city perspective, having PLs is beneficial, especially if they are an open network. It can be defined as an open PL network when it is not associated with any service provider, meaning any carrier can use the lockers to deposit its parcels (Prandtstetter et al. 2021).

This horizontal collaboration is crucial since it optimizes PLs occupancy rates and consequent economic viability, as well as the space used in the city (Ibid.). PLs goals are in line with the development of a fair and sustainable city by supporting access to time-poor workers, a substantial population group. It also favors business activity's locations and reduces the dependency on a motor-powered lifestyle (Lachapelle et al. 2018).

The municipality plays a vital role in ensuring a LT last-mile delivery system. They are the agency in charge of formulating regulations, making infrastructure investments, and putting city plans in place to mitigate the negative effects of urban freight transportation (UFT) while promoting eco-sustainable means (Stanisław Iwan, Kijewska, and Lemke 2016; Pronello, Camusso, and Valentina 2017; Trung et al. 2020). Besides this, municipalities might urge regulations that power sustainable delivery practices to assist unprepared carriers (Trung et al. 2020).

5.1.3 City Logistics: Sustainable City Mobility

City logistics is defined as the optimization process of transport and logistics supported by advanced information systems which, as stated by Taniguchi and Thompson (2002), "considers the traffic environment, its congestion, safety, and energy savings within the framework of a market economy" in the urban areas to achieve cost-efficiency and sustainable UFT (Cossu 2016). UFT is crucial in developing cities because of its importance for the economic system due to distributing goods. UFT faces four main challenges with regards to the last mile namely: high delivery costs, inefficiency, pollution - air and noise -, and congestion (Trung et al. 2020). In some categories, the carriers are the problem originator, meaning their activity is the source of the problem, while in others the carrier is the problem owner, meaning it is the one who suffers from the problem. Carriers were considered as a problem originator of congestion and pollution, due to their need for fast deliveries and the use of diesel vans. In the above-mentioned issues, the municipality was the problem owner along with the carriers on congestion issues (He and Haasis 2019). The carriers were viewed as problem owners in terms of high delivery costs and inefficiencies, whereas the problem originators were retailers and consumers (Ibid.). This said, the issues in which carriers are identified as problem originator are easier to resolve. In a study conducted by the Business School of Copenhagen, six performance indicators were analyzed to find an efficient and sustainable last-mile solution (Trung et al. 2020).

Eleven single innovations were explored, and the solution of night-time deliveries (NTD) was the only one classified as perfect in five out of the six KPI's. NTD solves congestion (cars/km), emissions (CO_2/km), speed (min/parcel), capacity (parcels/delivery run), and cost of delivery (cost/parcel), leaving only the noise (decibels) issue as unsolved (Ibid.). This occurs due to the time saved by using the roads during non-peak-hours (Bean and Joubert 2020); which on average, signifies 14,1% time saved (Verlinde and Macharis 2016). As a result, it inevitably creates fuel savings since the engine's running time is shorter. Accordingly, there is a reduction in vehicle dissipated emissions. Hence, costs are saved, even if night salaries are higher (Kurnia Yudha and Starita 2019; Fu and Jenelius 2018; Holguín-Veras et al. 2014). NTD reduces the CO_2 emissions and the city's congestion by 28,2% (WEF 2020). However, in some cases, implementing a NTD operation is difficult and disruptive in the short run (Bean and Joubert 2020).

The noise issue can be associated with the vehicle due to its engine or tires, and/or can be caused by supplying the goods, such as loading and unloading, or handling (Slávik and Gnap 2019). Though, there are ways to reduce the noise that might be caused. A solution can be the vehicle type or training the staff on doing their job at a reduced level of noise (Ibid.).

NTDs are an excellent solution to be combined with PLs due to its 24/7 availability. Moreover, it also has a more manageable disruption level by the logistic players than other consolidation solutions (WEF 2020). Combinations of single innovations are desirable to create the highest possible positive outcome for both public and private players. (Trung et al. 2020; WEF 2020). Concerning the KPIs formerly stated, PLs are ideal to improve the delivery costs and speed, but only half-perfect in terms of noise, congestion, and emissions. Nonetheless PLs still contribute to a 11,9% reduction of emissions and congestion (Ibid.). Regarding capacity, it is not the best option (Ibid.).

The WEF (2020) adds to the above-mentioned combination, the EV. In this way, the unreached KPIs can be improved since the noise emitted by the EV are minimal. Also, capacity issues can be optimized by offering a blended solution of night and day delivery. Moreover, connectivity solutions should always be added to optimize the delivery routes. In such a combination, local emissions are reduced by 30%, unit costs by 25%, and congestion by 30% (Ibid.).

5.2 Methodology

Complementing the available literature, a qualitative analysis was conducted with semi-structured interviews in order to collect specialized knowledge.

5.2.1 Semi-structured Expert Interviews

To improve the quality of the study, ten semi-structured interviews were conducted. The experts were meticulously selected to have a diverse sample in different aspects such as company geography, size, and PLs adoption phase. All experts occupy a C-level company position in companies such as Inpost (Poland), HiveBox (China), CTT (Portugal), Iboxen (Sweden), Smartbox (India), Swipbox (Denmark), Iboq.it (Portugal) and two last-mile consultancy firms. More detailed information about the experts is available in appendix 2b.

5.3 Findings

Cluster 1 – The importance of City Logistics. Almost all the experts classified City Logistics as highly important (five out of five), except E10, who works in a nationwide logistic company. As mentioned by E4, "The whole logistic infrastructure is changing because of the traffic," and by E2, "cities are getting crowded, and logistics are one of the biggest challenges in the growth of e-commerce and retail.". The same idea was shared by E4 and E9. Additionally, as expressed by E6, there is currently a "Low delivery density for "to door" B2C deliveries.". And, apart from not being recommended to bring more trucks in to the city, it is also becoming harder to find available courier drivers (E4, E7, E9). Another major challenge associated with City Logistics by the experts was the last-mile sustainability (E6, E5, E4), which is a topic that is rising in importance as stated by E4, and as expressed by E3 "We want to be a promoter and a driver of these themes in the cities we work. We believe that we should be a driving force together with the city councils to understand what future models should look like, not only on a sustainable environmental level but also on an economically sustainable one.".

Cluster 2 – Parcel Lockers as a last-mile solution and an enabler to improve City Logistics. Quoting E2, "Last mile is increasing the need for more cars on the streets, generating more traffic, more pollution versus an "optimal solution."" Therefore, "the last mile problem is that you cannot deliver enough with the current resources and time that you have" (E9). In this sense, all the experts agreed on the ability of PLs to improve city logistics due to its relevance as a solution to the last mile. Therefore, it was an opinion shared by many experts (E3, E4, E5, E6) that due to the e-commerce expected growth, an "out-of-home network should be developed as an ecosystem which offers service points and PLs simultaneously." (E6). To be considered as an interesting solution for the community, the PLs network needs to be open, or as called by the experts, needs to be an agnostic network (E6, E1). Starting from a broader perspective, that is to say the city, it improves its mobility since by consolidating many parcels it results in "less motor traffic and in a decreased need to go into town after your parcel" (E1). In other words, by having a dense and well-located lockers network it "reduces the number of stops and enables the quantity of trucks that have to go into the city to be reduced" as mentioned by E4 (and E3, E7, E9). Additionally, consumers do not need to drive as far (E5), or better, they can walk, use public transports, to their preferred locker, or even have them incorporated in their daily routine (E4, E3, E9). As a result, it "can help reduce the carbon footprint hence more packages can be delivered in one trip, contrary to door delivery." as mentioned by E2 (and E3). Consequently, this consolidation system improves its effectiveness (E5, E3) while reducing its delivery costs

(E3). "There is almost 100% effectiveness regarding the first trial parcel delivery unless the locker is full. And this is a key aspect", as mentioned by E3. "Parcel delivery companies can deliver “en masse” and not be dependent on people being home" (E1). E5 said that on average, in Sweden, 10% of the parcels are not delivered in the first trial in-home deliveries, which means that those need to be re-done, leading to extra pollution for the environment. Also, by the PLs being static, it saves the driver a substantial time finding the location (E5). Furthermore, by combining the digital with physical infrastructure, both "have the same information at the same time, every day" and can act accordingly, as they have immediate and convenient access to their parcels (E5, E9). The aforesaid ideas explain the customer time difference when picking up a parcel in a PL, which takes 10 hours on average and where 20% of the orders are collected in two hours, compared with the 1,8 days in a service point (E5). PLs are considered "the most convenient way for people to pick up a parcel," as mentioned by E4. The benefits of PLs for B2C are the extended schedules for consumers to pick up their parcels (E3, E5, E1); and its flexibility to be installed where consumers "work, live or go shopping" (E1, E3). "B2B also demands easier and more convenient logistics," (E4). As E1 said, "lockers can play a role for everyone" by "optimizing the last or the first mile" (E7, E1).

The experts highlighted the limited capacity of the PLs as a limitation (E7, E1, E3, E8 E9). However, the solution enables the provider to adapt by adding modules to the current locker. Though, there can still be space limitation if the location does not support more extensions (E9). Nevertheless, a PL gives more flexibility in this sense than service points (E3). PLs are less efficient as the parcels need to be inserted one by one in the lockers compartments (E8). Another limitation is the Capex needed to finance the project (E2, E4).

Finally, PLs can even be seen as a driver of e-commerce in two situations. First, for workers with poor schedules, such as doctors, nurses, or factory workers, e-commerce was not a reasonable solution due to the difficulty of access (E7). Second, for the population living in more remote area, picking up a parcel requires traveling several kilometers (E5). In this way, it creates accessibility for two unfavored e-commerce groups.

Cluster 3 – Need for a contribution by the different stakeholders. "Everyone in the chain should contribute a little to bring superior adoption of the lockers" (E2). That is the reason why it is essential to "Find a model that everyone is good at adopting, which has a centralized logic, where everyone improves its current status quo" (E3). Therefore, it is time to stop worrying about the customer and start working together on the last mile. (E5).

Starting with the government and municipalities, in some cases, there is a "lack of information and understanding of this field by taking only the sustainable perspective of the situation, which will end up in bottlenecks" (E4). Municipalities should support this solution by helping the locker providers, as well as offering quick and easy access to public convenient space locations (E4, E3, E2, E5, E9). Municipalities need to "recognize that PLs are an alternative delivery channel that helps and decongests their city," as mentioned by E2. Essentially, the city should treat an agnostic PLs network as an important infrastructure, as water or gas system. (E4). It is necessary to educate governments and private property owners about the solution in order to appropriate PL locations to be approved fast (E5, E7). And, the reasons for it should be the benefits they are promoting, such as productivity, safety, sustainability, and convenience, all of which contribute to a better city (E5). Additionally, the "government needs to create rules to guide the logistics companies because they have no time to improve their models properly with the current parcel orders increase," (E4).

On the other hand, customers must adopt the solution; otherwise, results cannot be seen (E3). E2 believes that parcel "lockers need to become a cheaper delivery option because you need to increase their utilization and adoption in the market. For that, you need to offer them at a discount. So, door delivery should be a premium product, and locker delivery should be a cheaper product." All in all, in the Nordics, this solution has been massively adopted; is located in Poland one of the most extensive worldwide lockers networks, totaling 15 000 PLs installed, and with the goal of creating a full ecosystem centered in PLs (E9). As a result, 80% of parcels are currently delivered in a PL (E7). However, Inpost still believes that they can increase the number of their lockers at least two-fold from the current numbers (E9). Similarly, in China, with a 150 000 PLs network, 90% of the people prefers to receive their parcels in a PL (E8). Therefore, it highlights the need for scale in this business.

Cluster 4 – Flexibility and Adaptability of the Parcel Lockers. The PL must be seen as a helpful solution to optimize any interaction exchange that may need validation, between two people, where traditionally they had to move to the same place, at the same time for an exchange that takes five seconds (E7.). "It can be a solution for the first or the last-mile, and it can be evenly applied in business cases separately from the logistics sector. (E7). Some additional use-cases increasing its importance in this business are the returns (E3, E4) and service automation (E3, E7). Additionally, there are plenty of other solutions that can be considered, such as refrigerated lockers (E3), larger lockers (E4), or even the keys of a house rental (E3).

Furthermore, using technologies such as "Big Data, the company can understand the utilization of the locker and improve it accordingly" (E4), also mentioned by E8 and E5.

Cluster 5 – Combination of single innovations: open Parcel Lockers and night-time deliveries. The combination of NTD with PLs was considered a good solution, on average, for the current logistics problems of cities with a classification of 3,7 out of five. Three experts classified it as an absolute five (E1, E4, and E5). Four experts classified it as a four, referring three reasons: first the need of a solid scale to become an efficient business model (E3), second this solution does not solve all the problems (E2) and third the associated difficulties (E7, E10). E8 classified it as a three out of five, due to a similar reason as E2, "only focus on the last mile and the biggest problems of city logistics are in the last 10 miles or the first mile," (E8). E9, classified it as a two out of five since he believes that the furcal aspect is the parcel arrival in the locker and therefore other models can work too, as will be described further on. Finally, E6 classified it as a one referring that: "I see this as an unfeasible solution by most of the carriers due to very high costs, not only for the last mile but for the entire network.". Excluding E6 and E9, every other expert agreed to some extent on the benefits associated with this combination for the last mile: "That's one of the ways of addressing the city challenges by aligning night deliveries with lockers." (E2) or "That's the only solution to start delivering at night" (E3).

The main benefits pointed out by experts were the following. Starting from a logistics company's point of view, as mentioned by E3, "during the night, the mobility of vans is better, since there is less traffic and congestion, and it is easier to park.". E5 also mentioned this idea. E5 also stated that more parcels could be delivered, and therefore "the productivity increases significantly which is good for sustainability purposes and is good for the logistic company profitability." Even if you must pay more to the employees during the night, the productivity gained pays off that additional cost (E5). E5 concludes by saying: "sustainability and city logistics from an infrastructure point of view doesn't necessarily mean it will hurt profitability. In fact, it will increase profitability.". Additionally, "Couriers need all the time available" (E4) if the e-commerce continues to increase as it is predicted" and "all delivery companies are driving in the same period 8 am to 9 pm; by 2025, it will be needed more than 5000 cars, only to drive home deliveries to consumers. And the assets then stand still 12 hours a day" (E5). The combination in the analysis also improves the utilization of the assets (E5). According to E4, E5, and E2, there is no need for incentives since logistics companies will create value by augmented productivity. Therefore, it should be considered as a natural development since many other items are also delivered at night (E4). According to E5, "improvement of around 25% to 30% of productivity can be seen, even without considering that the locker can be used twice". Even with a salary increase of 15% to 20%, there is still a 5% to 10% net improvement. However, on the other hand, two experts with experience in logistic companies (E6, E10) commented that "large international carriers do not offer special or dedicated routes for B2C only. Therefore, such a solution is operationally and economically inefficient. The key for efficient operation is the highest possible density (delivery/pick up stops) on the route." (E6), whereas E10 commented that it depends on the supply model used. If the logistics company can receive the objects from the entire country before starting the delivery to the lockers, and if it has the scale needed, a dedicated route to supply the lockers, then it can be considered a possible option. Additionally, E9 does not fully agree with this strategy. However, its company's first locker delivery starts around 6am. They do not start delivering to the PLs earlier because the sorting operations are organized to occur during the night. Their main delivery method is through PLs and as end-consumers do not pick up their parcels during the night, this model does not add value to them. Instead, they deliver to the PLs as many times as possible during the day. In China and Sweden, this model is currently adopted. "In China, we do like this. Goods arrive in the sorting center at 02:00 am, then they are transported to locker directly, arrive in a locker at 04:00 am" (E8). They believe that supplying products more rapidly is one method to keep providing clients with what they require. For that, either the retailer has a "high density of micro warehouses or a PL delivery at night is the solution for the 24h delivery" (E8). In China, the adopted model incentivizes the NTD by not charging the carrier to use the locker (E8). Therefore, the companies opt for this delivery type whenever needed (E8). Moreover, E8 believes the e-commerce companies should sustain this adoption of value creation NTD by promoting the convenience of having the product available next morning in a PL nearby their apartment. This combination also increases convenience for the consumer since by doing night deliveries, the parcels become available to pick-up when the consumers wake up (E5). As mentioned by E4, statistically, "80% of the users will pick up the parcels before going to work". Additionally, "it is making it possible for the lockers to be used at other times during the day" (E5). E7, E4 also mentioned this idea of a blended night and day delivery solution. However, the current struggle of finding carrier drivers for daily deliveries can be increased once considering night shifts (E7). In terms of drawbacks, noise was reported as not being an issue since other night services also operate in the streets. Moreover, the last-mile vans are small, and the locker system is smooth (E3, E10, E4, E2, E1). However, E6 and E7 "consider that NTD for residential areas will be inconvenient for residents due to noise.". E5 affirms that it is a "condition for night deliveries to have an electric or environmental vehicle." The continuous lease arrangements proved a difficulty for E5 when it tried to expand its network of NTD carriers. The fleet can only become electrified after maturity.

5.4 Discussion

E-commerce is a buying behavior that has come to stay. Hence, it has heavily impacted the logistics operator's business and, thus, the cities' current and future logistics problems. PLs have arisen as a solution to mitigate the problem by offering convenience to the end-consumers while creating efficiency in the drivers' logistics trips and consequently contributing to a more sustainable city. However, to take full advantage of a PLs innovation, the scale of the network and the scale of the clients' adoption of the service is essential. Therefore, the first step is to ensure that the end-users know the lockers' existence, their convenience, and also their way of use. Likewise, making this network wider should be the responsibility of all stakeholders involved by streamlining the process of parcel the lockers' location permission.

The literature review confirms the improvements made by the PL in CO2 emissions and congestion. However, if this solution is combined with NTD, the results will be extended to their maximum in terms of emissions and congestion. Moreover, an electric vehicle fleet should be added to the existing fleet to decrease noise and emissions. Furthermore, the locker top up must occur in a blended model, meaning that a night-time exclusive delivery would not solve the problem, especially when the solution become popular. In terms of productivity, even though the literature sustains the idea of reduced delivery costs by adopting the referred combination, some of the area's professionals do not support this. In some countries, the way logistics companies are optimized for their current workload does not permit a full restructure to deposit the parcels during the night in the PLs. In many cases, this is a fact because the company's long-haul transportation within the country occurs during the night-time. Therefore, it is not advisable to deposit the parcels in the PLs in a NTD with only the arrived parcels; unless those are sufficient to fill the entire PL. Additionally, companies that offer both home and PL delivery methods see the PLs as more beneficial if they can take advantage of the synergies. This means that in this kind of companies, as PLs use increases, firms should adapt their model to a blended one and take advantage of NTD to deposit in the PLs and produce internal-, city-, and consumer benefits. Inpost is an example of a company which the main business consists of delivering in the parcel lockers. Therefore, by having its own hub to receive all the parcels and its own fleet to deliver the parcels throughout the day the is optimized to top up the lockers as many times as possible, nonetheless the company starts the first delivery very early in the morning (around 6 am). On the other hand, in a country as China, where its PLs network is 100 times bigger than Poland (the biggest European PLs network), they are already optimized to do NTD.

To conclude, there is no unique solution that fits all business models. However, sustainability and city logistics are topics that every city stakeholder should consider.

5.5 Limitations and Future Work

The greatest limitation of this research is the carriers' operations being organized to optimize the current needs and functioning model. Additionally, since the PLs adoption scale in the different countries is not similar, the need for improvements and adjustments are not seen as incremental by all the nations. Hence, individual analysis of the current operating system and evaluation of how advantageous adapting its logistics to NTD to the PLs, should be studied in future projects, as well as the individual impact of its adoption in the city in concern.

6 Conclusion

This paper examines and analyzes different ETs and their applications available to support SCM activities. Based on the secondary data reviewed in the research paper, it is evident that Industry 4.0 can be applied to the entire SC in different areas.

Since today's SCs are facing many turbulences, organizations are increasingly pushed to deploy ETs in SCM (Nitsche and Straube 2020). These technologies enable organizations to become more robust and agile to thrive in uncertain and competitive market environments (Wang, 2018). ETs, such as IoT, Data Analytics, and AI were highlighted as main enablers of digital SCM. The research paper presents that organizations can adopt those technologies throughout the SC to create new business value from operational efficiencies, cost reductions, and enhanced customer loyalty. However, the research shows that companies are also facing challenges when deploying ETs. Major challenges highlighted by literature include stakeholder resistance to new technologies, missing change management, insufficient cost and resource management, and insufficient cybersecurity.

Agility builds one of the most important principals of today's SCM. The implementation of ETs establishes a foundation for the four pillars of agile SCM. Market sensitivity, connectivity, virtuality, and process integration allow organizations to increase their responsiveness, reliability, and quickness to manage SC processes. Vertical integration along the SC allows leveraging those pillars, while increasing efficiencies and improving value proposition.

While there is a large amount of research available on the fundamentals of digital SCM, four topics were identified as little studied before. By focusing on those four diverse topics, the study successfully contributes to current research by building on and extending previous studies.

Section 4 shows how AI can be leveraged in procurement. The study presents AI application areas within the P2P process and strategic sourcing to consolidate and automate procurement activities, achieving higher levels of transaction automation, efficiency, and effectiveness.

Expert interviews illustrate that procurement professionals are generally aware of application areas but are still far from fully implementing AI. Experts highlight that either a technological foundation is missing, or daily challenges outweigh implementation advantages. However, there is no doubt that AI is the next driver of innovation in procurement. Therefore, AI will become an embedded, foundational layer for procurement, but its implementation will still take time. Hence, procurement professionals shall prepare for the evolution of the procurement function, moving towards more strategic tasks.

Section 5 discusses how RSs can be used to increase SC agility and elaborates a conceptual framework for RSs in SCM. Once successfully deployed, RSs enhance SC agility by providing recommendations based on SC variables such as delivery times and constraints, product location and availability, or demographic and geographic details. Further, this section shows that even though the use of RSs in SCM represents a well-conceived concept in theory, developing a reliable RS for SC purposes requires thorough and time-consuming preparation. Lacking data quality and availability, missing business readiness, or the lack of a proper DS strategy may prevent companies from realizing the potential of RSs in SCM. However, companies that succeed in implementing RSs and use them to optimize SC processes will have a significant competitive advantage in the future.

Moving further, section 6 presents the combination of parcel lockers and night delivery to reduce carbon emissions and city congestion. Currently, many companies use night shifts for long-haul parcel transportations and not for last-mile deliveries. Therefore, even though the literature confirms that it would be cost-effective to implement parcel lockers in combination with night delivery, in most of the cases carriers' logistics operations would need a huge restructuring.

Finally, section 7 covers the topic of vertical integration as an enabler for quick commerce. By demonstrating the advancements of verticalization along the integrated SC, many benefits of the business model were carved out. Neither the unit-economics, nor the value proposition itself would be feasible without integration, which further highlights the crucial role of gathering and interpretating data for real life applications. Improved monetization, efficiencies and environmental sustainability of the quick commerce model have far-reaching implications for the overall FMCG and retail market, amplifying the role of agile SCM.

In conclusion, this research paper demonstrates an accelerated importance to gather, process, analyze and interpret data to realize economic, social, and environmental SC benefits. While integrating ETs may be challenging for many companies, those technologies and their deployment will play a critical role in the future of SCM.

Further, AI has the potential to challenge the traditional rationale behind optimization. Instead of incremental innovation, thoroughly done by specializing on one specific step of the value creation process, AI enables organizations to optimize based on a large amount of data. Therefore, the strategic advantages of vertically and horizontally integrated large-scale businesses potentially increases, leading to fewer, more dominant companies over time.

In addition, sustainability is becoming increasingly important for differentiating between competitors. The study shows that AI and IoT can support companies in identifying SC sustainability improvements and enable the achievement of sustainability goals. As such, ET capabilities allow companies to significantly reduce error rates, lower operating costs and streamline SC flows. Further, by supporting resource management, ETs help companies to reduce the consumption of scarce natural resources, while eventually increasing profit margins. This helps reduce companies' carbon footprint and facilitates the implementation of the circular economy concept.

7 Limitations and Future Work

The research discovered that there are differences among experts in the acceptance and implementation of ETs in SCM. Despite the theoretical and managerial contributions of digital SCM, this study reveals several limitations.

During this research, a relatively small number of interviews have been conducted, resulting in limited insights about ETs in digital SCM. Since expert knowledge depends on individual experience and understanding, the accuracy of the gathered data cannot be fully guaranteed. Moreover, the study is limited by the unwillingness and inability of experts to share insights and data with the interviewers. To increase the validity of this study, future research which incorporates more in-depth expert knowledge and considers companies with different exposure to ETs is needed. Given that some countries may be at a different stage of technology adoption than others, it would further be beneficial to expand the geographic scope of expert interviews.

In addition, limited studies available and highly diverse data sources have made the literature search and selection process time-consuming, laborious, and difficult. The primary use of the three databases Scopus, Nova SBE Discovery, and EBSCOhost to collect insightful articles for this research resulted in eventually omitting relevant articles that may not be listed in these databases. Therefore, the use of a wider range of databases and alternative data sources may improve research results.

In order make this study more comprehensive, different areas within digital SCM shall be further investigated.

Interestingly, the findings of chapters 5 and 6 show a high similarity in terms of AI and ML implementation requirements, regardless of their application in SCM. Future work shall therefore merge the implementation guidelines derived from the research to build a joint framework for AI implementation in SCM.

With increasing connectivity and virtuality of processes, the need for effective cybersecurity solutions is growing rapidly. Highly competitive markets are pushing firms into heavy cybersecurity investments. Future research should therefore explore cybersecurity practices, such as federated ML. This concept enables SC stakeholders to maintain the confidentiality of their data while leveraging it with other business partners to accelerate SC digitalization and generate sustainable competitive advantages.

In terms of sustainability, none of the experts interviewed mentioned SC sustainability as a primary application area for ETs. However, as this topic is increasingly used to gain competitive advantage, both researchers and practitioners should more thoroughly explore how ETs can improve SC sustainability.

Future studies could also explore the role of ETs from the perspective of organizational information processing and resource analysis to develop the necessary level of SC resilience in uncertain times such as COVID-19. Additional research may as well compare changes in SC resilience before and after the occurrence of COVID-19, as well as explore the potential for ETs to increase SC agility in the case of unforeseen events.

Finally, it should be noted that a larger time and content frame for this study would have allowed a more detailed investigation of ET applications in digital SCM. In summary, this study offers many opportunities for further interesting, timely, and topical work.

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9 Appendix

Appendix 1: Digital Technologies catalyzing Business Model Innovation in Supply Management

Appendix 1a: Literature, Theoretical Background, and Definitions

Enablers of Digital Supply Chain Management (Section 3.4)

<u>IoT – Network Types (Section 3.4.1)</u>

There are different types of networks in IoT, including PAN, LAN, WAN, and cloud.

Network Type	Definition
PAN (personal area network)	- small networks where connected wireless devices are within personal reach - Example: Connecting your smartphone to your car using Bluetooth
LAN (local area network)	- networks in a small or local geographic area, such as a home, small business or department within a large corporation - can connect two or more devices, including computers, printers, and wireless devices - access to larger wide area networks (WANs) and the Internet
WAN (wide area network)	- collection of LANs that provides inter-LAN and Internet connectivity for businesses and governments
The Cloud	- collection of data centers or groups of connected servers that are used to store and analyze data, provide access to on-line applications, and provide backup services for personal and corporate use

Machine Learning – Terminology (Section 3.4.4.2)

Term	**Description**
Instance/example	Representative for a fact or data point described by a set of features
Feature/attribute/predictor/input/independent variable	Variable describing the underlying data, individually measurable property or characteristic of a phenomenon being observed
Numeric feature	Data having an order (e.g., height, age)
Categorical feature	Unordered data (e.g., color, country)
Label/target/outcome/dependent variable	Unknown value of interest; variable that is predicted
Model/algorithm/learner	Formula or function created for a specific purpose; the machine automatically learns the formula on its own without knowing it priorly
Training	The process of creating or learning the model from data
Inference	Applying the trained model to make predictions on new/unseen data
Prediction	Estimate of an unknown value (target) – in this context it does not imply forecasting/prediction of the future, but it estimates the value of interest, which could be from the past, present, and future

Machine Learning – Paradigms (Section 3.4.4.2)

The most common approach to categorize ML techniques is by the level and type of supervision the training of a specific model requires. The four main learning paradigms include supervised, semi-supervised, unsupervised, and reinforcement learning (Mohri, Rostamizadeh, and Talwalkar 2018). Each of the approaches will be elaborated in detail in the following sub-sections.

Supervised Learning. Under supervised learning a ML model learns a function by mapping a feature to a label based on known feature-label pairs. Given the set of features and labels in the training data, the model will then predict a label to a new feature set. Within this learning approach, there are two types of supervised methods. Classification models predict a category of instances among two (binary classification) or more discrete classes (multiclass classification), whereas regression models predict continuous variables (Mohri, Rostamizadeh, and Talwalkar 2018).

Unsupervised Learning. Unsupervised ML is an approach mainly used to detect hidden patterns in data. The algorithms are trained without labeled data and independently recognize all unidentified existing structures in the training set to derive rules form them. The most common use of unsupervised ML is to assign data into groups of similar examples, known as clustering (Alzubi, Nayyar, and Kumar 2018).

Semi-supervised Learning. Semi-supervised learning combines small amounts of labelled data with larger amounts of unlabeled data during training. Given a set of features and a small set of labels, the algorithm predicts a label to a new feature set, performing better than if developed using only labelled data. As such, this approach represents an intersection between supervised and unsupervised learning and is considered a special form of weak supervision. Semi-supervised learning can be beneficial when labeling is costly to learn, yet a large set of examples does not have labels (Goldberg 2009).

Reinforcement Learning. In reinforcement learning, a model is learnt in a special context, where an intelligent learning system observes the environment, selects and performs actions and receives rewards or penalties in return. The goal of reinforcement algorithms is to maximize the value of cumulative rewards through feedback after a sequence of actions (Sugiyama 2015).

Machine Learning – Model Development (Section 3.4.4.2)

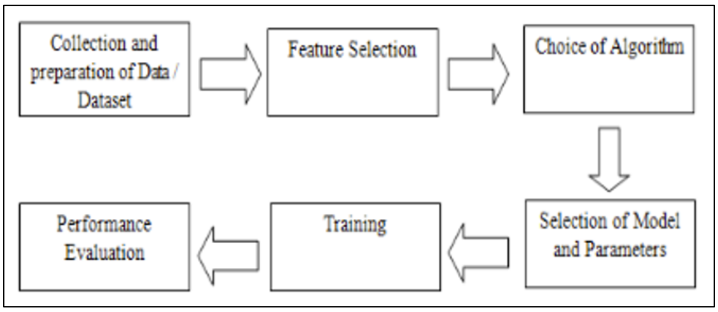
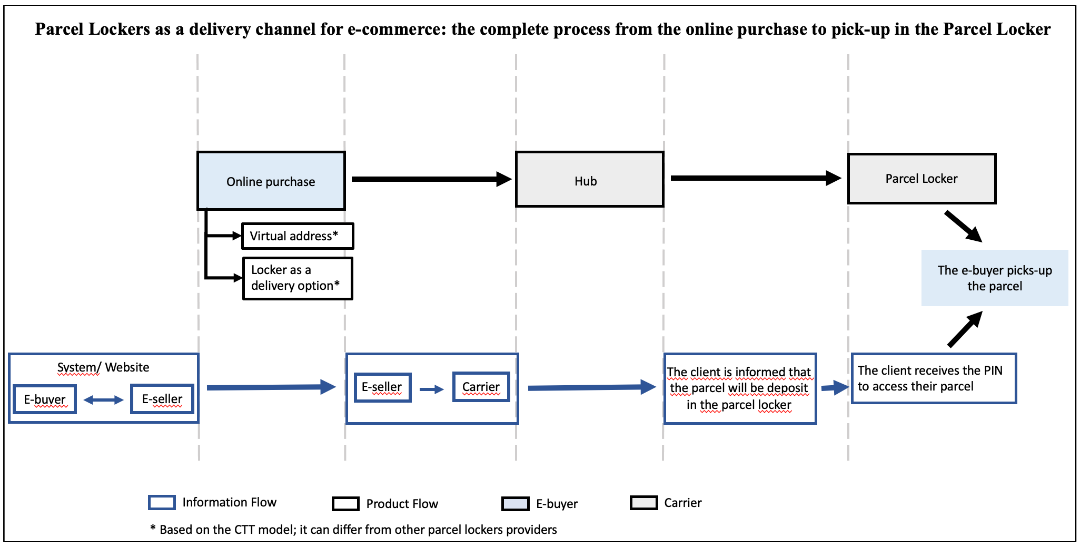


Figure 1: Stages of Machine Learning Model Development

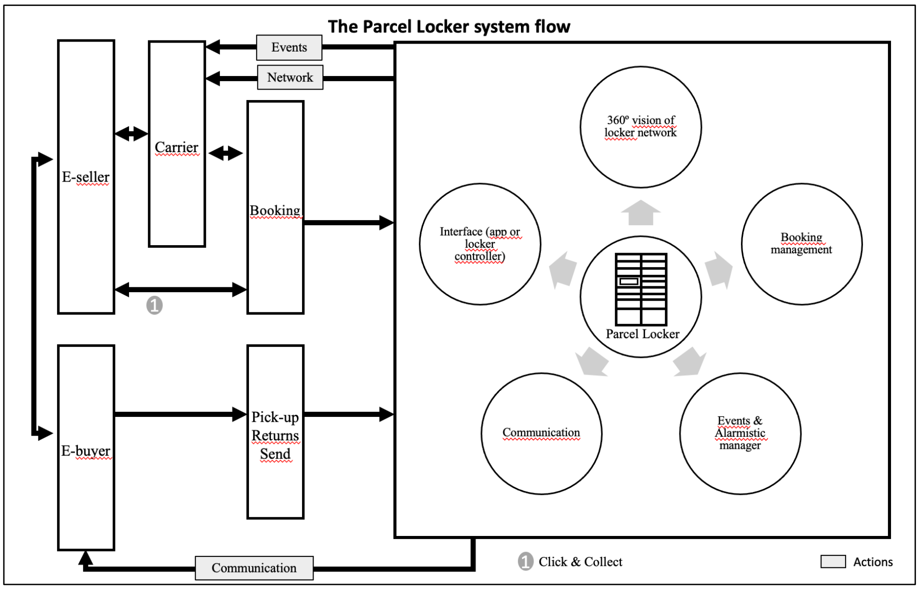
Appendix 2: Intelligent Parcel Lockers as a Solution for Improving Sustainable City Mobility

Appendix 2a: Parcel Lockers – Explanatory Schemes (section 5.1)

Parcel Lockers as a Delivery Channel for E-commerce: the process



Parcel Lockers System Flow



Appendix 2b: Expert Interviews – Expert Overview (section 5.2)

Expert, Name, Country, Position and Previous Experience

ID	Name	Country	Position & Co.	Previous relevant experience
E1	Lars-Christine	Denmark	• Chairman at SwipBox (the company that have developed the battery locker) • Vice Mayor and Vice Chairman of City Planning & Technical Committee at Liberal Alliance	-
E2	Amit Sawhney	India	Co-Founder & CEO at Smartbox	-
E3	Francisco Travassos	Portugal	Head of Strategy & Business Development at CTT	• Team Lead Business Development & Digital Transformation at CTT • Consultant at Bain
E4	Peter Bonefeld Ronde	Denmark	• CEO at PBR Consultant (Consultancy company in the field of last mile, e-commerce, and parcel	Chief location officer at SwipBox Business Development Specialist: OPS, e-commerce and last & first

			lockers) - currently responsible for the infrastructure creation of parcel lockers in Romania • Pro Partner at Last Mile experts	mile solutions at Interim management consulting
E5	Tim Jornsen	Sweden	CEO and Co-founder at Iboxen	Executive vice president logistics and e-commerce member of the group executive team at PostNord (PostNord is a company which offers parcel lockers)
E6	Mirek Gral	Poland	Vice president & Partner at Last Mile experts	UPS Division Operations Manager
E7	João Lopes	Portugal	COO and Co-founder at Bloq.it	
E8	Tommy Xu	China	Head of International Business at Hive Box	
E9	Marcin Baginski	Poland	Head of Business Development Department at Inpost (the largest operator of parcel lockers in Europe)	Management Consultant at BCG
E10	Paulo Alexandre Silva	Portugal	Head of R&D - Production and Logistics at CTT	

Expert Name, Interview Duration, Contact Method, Interview Method

ID	Name	Interview duration*	Contact method	Interview method	Recording allowance	Authorization to share the expert name, company, and position
E1	Lars-Christine	N/A	Linkedin	Email interview	N/A	Authorized
E2	Amit Sawhney	15’’08’	Linkedin	Teams	Yes	Authorized
E3	Francisco Travassos	23’’44’	Email	Teams	Yes	Authorized

E4	Peter Bonefeld Ronde	35''53'	Linkedin	Teams	Yes	Authorized
E5	Tim Jornsen	46''44'	Linkedin	Teams	Yes	Authorized
E6	Mirek Gral	N/A	Linkedin	Email interview	N/A	Authorized
E7	João Lopes	23''56'	Linkedin	Teams	Yes	Authorized
E8	Tommy Xu	20''22'	Linkedin	Teams	Yes	Authorized
E9	Marcin Bag-inski	44''24'	Linkedin	Teams	Yes	Authorized
E10	Paulo Alexan-dre Silva	~ 45'' (not recorded)	Email	Teams	No	Authorized

Interview Questions

1	How important is the topic City Logistics for your company? 1.1. Can rank on a scale of 0-5; 0 is the lowest and five the highest
2	What do you think that are the major challenges in city logistics?
3	How important do you think that intelligent parcel lockers are as a solution for the last mile?
4	How do you think that parcel lockers can improve city mobility/city logistics?
5	What do you think that are the main limitations in the parcel lockers?
6	Considering the city logistics main challenges, do you think combining a parcel locker with night delivery can be a good solution to improve the current city logistics challenges?
7	In your opinion, which incentives/approaches could make this night delivery in parcel lockers generally or easily accepted?
8	To conclude, from 0 to 5, being 0 the lowest and five the highest, how much do you think this combination is good for improving the city logistics current problems?
Additional questions for the experts with previous experience in logistic companies – in all cases the company have not adopted any kind of night-time delivery model yet.	
A	Do you think (Company) would adopt an off-peak hour delivery strategy? For example, night delivery?

B	Why do you think (Company) would adopt or not this strategy?
C	(If answered, would adopt in the previous question) Would it be easy for UPS to do it?

Note: The night-time delivery schedule defined was between 10 pm and 6 am and it was based on the article *Transport efficiency of off-peak urban goods deliveries: A Stockholm pilot study* (Fu and Jenelius 2018).