Challenges and Opportunities of Interoperable and Future-Oriented Technologies for Production Logistics and Supply Chain Management

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Summary

The increasing use of future-relevant technologies and also the applications of Artificial Intelligence are increasing both in production logistics and Supply Chain Management. Companies can only respond to the new challenges of adaptability, scalability and individualisation of customer needs through the use of future-oriented technologies.
This article describes the current state of technological developments in production logistics and Supply Chain Management. Following the introduction to current trends, the state of the art and selected action research approaches will be presented. In the area of production logistics, the topic of interoperability is a key factor. New networking approaches of autonomous systems in the internal environment will be discussed. The second approach, Supply Chain Management, deals with the use of new technologies, in particular Artificial Intelligence for processes in the external context. Finally, digitisation in production logistics and supply chain management will be discussed.

Word Count: 5,051

1 Introduction

Over the course of the last years, increasingly uncertain and challenging business environments have led to companies trying to establish more responsive and resilient supply chain structures. Both man-made and natural disasters come to mind when considering possible impact factors on one's organisation's flow of material (and information).

Recent examples include German companies involved in business with, or even producing within, the UK preparing for what has become known as the option of a hard Brexit (Reay, 2018). According to the Handelsblatt (2018), the rising probability of a hard Brexit has alerted German businesses as they fear the implications on export and import of goods. Reay (2018) puts the number of German companies operating in the UK at 2,500, employing around 400,000 people. This includes global organisations such as BMW, Thyssen-Krupp or Siemens. For companies managing increasingly complex and multinational supply chains, this clearly poses a threat to the smooth operation of their supply network. Apart from the financial impact, a no-deal Brexit could also mean stricter border controls and therefore delayed or even halted shipments. Consequently, especially manufacturing companies are observed to be building up additional storage capacities on both sides of the Channel as well as intensively cooperating with suppliers (Reay, 2018). The Financial Times, amongst others, has also published a list of steps for UK companies to follow in order to prepare for a hard Brexit (Giles, 2017). Not surprisingly, this to-do list emphasises on Supply Chain Management (SCM), including supply chain risk assessment.

Another omnipresent impact factor on supply chains are natural disasters. As could be observed in 2010, the eruption of just one volcano in Iceland brought European air transport to a halt for several days (Anon, 2010). In total, airlines were estimated to have lost £130m per day while providers of alternative transport options such as ferries observed an increase in customers (Anon, 2010). Concerning the import and export business, business trading perishable goods such as flowers experienced substantial disruptions to their supply chains.

In recent years, technological developments have enabled companies to better prepare for and manage supply chain disruptions. The present paper aims to determine what opportunities and challenges could be presented by the implementation of future-oriented technologies in production logistics and Supply Chain Management. Different conceptual approaches were used to answer the research question. First, findings on interoperability in a production logistics context from a PhD project are presented. Second, the concept for a PhD project covering the application possibilities of Artificial Intelligence in SCM is outlined. The paper follows a similar structure, introducing the state of the art of future-oriented technologies in production logistics and SCM. Thereafter follows the presentation of research findings concerning technological applications in production logistics and SCM before introducing an outlook to digitisation in those two areas and the concluding remarks.

2 State of the Art

2.1 Production Logistics

In modern production companies there is a multitude of technological developments, especially in the field of connected automation solutions. In addition, not only the trend towards adaptability and connection capability is emerging, but also the resource-efficient consideration of a factory system is becoming increasingly important. This influences both the factory planning process and factory operation process (Schenk & Wirth, 2004, p. 7) as well as the logistics systems themselves. In the development trends of the digital factory, Industry 4.0, and Internet on Things (IoT), the domain of interoperable connection is essential for a successful development of these trends.

Interoperability refers to the ability of independent, heterogeneous systems to work together as seamlessly as possible in order to exchange information in an efficient and usable way without the need for separate interfaces between the systems (Schleipen, 2012). The IEEE Standard Computer Dictionary defines interoperability as "The ability of two or more systems or components to exchange information and to use the information that has been exchanged" (IEEE, 1991).

Yet, a target-oriented and smart connection has an essential value in the trend of the digital factory. The digital factory describes the networking of plants, machines, employees and automation systems within a company as well as the networking of suppliers or other companies across company boundaries (supply chain management). The digital factory is a generic term for a comprehensive network of digital models, methods and tools (e.g. simulation and 3D visualisation), which are integrated by a continuous data management. The goal is the holistic planning, evaluation and continuous further development of essential structures, processes and resources of the real factory in connection with the product (VDI, 2008).

The approach of the Digital Factory should provide the necessary infrastructural information and communication basis for the continuous planning and operation of logistics facilities and logistics networks and ensure and further develop interdisciplinary cooperation within the company as well as across several organisational units and company boundaries. (Bracht, Geckler, & Wenzel, 2011, p. 45)

In the logistics environment of production, there is currently only initial development in tool to interoperable approaches, in contrast to manufacturing. A widely used approach for logical interfaces refers to machine and plant control at Manufacturing Execution Systems. (VDI, 2013)

The manufacturing systems should be adaptable and the levels of a factory should have this adaptability. Each level is characterised by different heterogeneous software systems with non-standardised interfaces that have to be adapted in case of possible changes. IT systems for operational business processes (control and monitoring) are upstream of the IT systems of the Digital Factory (administration of factory planning data). When changes occur, these are usually implemented in the IT systems of the digital factory and then introduced into the real world. In practical applications, changes to production systems lead on the one hand to the spatial "relocation" of the systems in the factory, and on the other hand to an increasing number of software adaptations. The latter are necessary due to embedded software in field devices (e.g. sensors, drives, valves), the controlling software of machines and plants (e.g. programmable logic controllers) and the software that is superimposed on the direct plant control. (VDI, 2013, p. 4 f.)

The interoperable approach is also important for the development of Industry 4.0. This essentially refers to the technical integration of Cyber-Physical-Systems (CPS) into production and logistics, as well as the use of the Internet of Things and services in industrial processes - including the resulting consequences for value creation, business models and downstream services and work organisations.

Furthermore, eight potentials were identified:

- individualisation of customer requirements
- flexibilization
- optimised decision making
- resource productivity and efficiency
- value creation potential through new services
- demography-sensitive work design
- work-life balance
- competitiveness as a high-wage location (Kagermann, Wahlster, & Helbig, 2013).

Logistics is also regarded as an outstanding application domain of the fourth Industrial Revolution. On the one hand this is due to the fast-growing technological developments. On the other hand a multitude of technical and social challenges are directly and indirectly shaped by logistics and connected with an efficient Supply Chain Management (Bauernhansl, Hompel, & Vogel-Heuser, 2014, p. 615).

The use of autonomously operating systems in companies and in particular in logistics facilities, which is being promoted in Industry 4.0, will lead to a high quality of mobility, modularity, compatibility, universality and scalability. In a similar approach Warnecke (Warnecke, 1996) developed the fractal factory as a production model. According to this approach, decentralised structures with local control loops as fractals can be found in a factory system. The aim of these fractals should be to act autonomously and to optimise oneself. Through the technological possibilities of self-control and adaptation to different tasks that emerged in Industry 4.0, the creation of a fractal factory becomes technologically possible. This IT networking of autonomous production fractals is also transferable to the entire supply chain (Bauernhansl et al., 2014, p. 621). An interoperable approach is necessary in the development of the information technology networking mentioned above.

The term "Internet of Things" is already encountered during initial research in the area of factory and logistics systems. The International Telecommunication Union (ITU) for example, defines IoT as follows: "A global infrastructure for the Information Society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies" (*International Telecommunication Union*, n.d.).

This definition clearly shows that the IoT must also have interoperable information and communication technologies at its disposal. Further definitions aim at three main topics (see figure 1). These are "things", "internet" as well as "semantics" (Atzori, Iera, & Morabito, 2010, p. 2789) According to this overview the combination of the three visions is decisive for the existence of the IoT. For only in the overlapping area of all three visions can one speak of an Internet of Things. IoT solutions and application areas are growing almost daily and are finding their way into many areas of the modern working and social world. Well-known areas of application include Smart Industry, Smart Home, Smart Energy and Smart Transportation. The Smart Industry sector is often discussed under the heading Industry 4.0 (Wortmann & Flüchter, 2015, p. 221 ff).

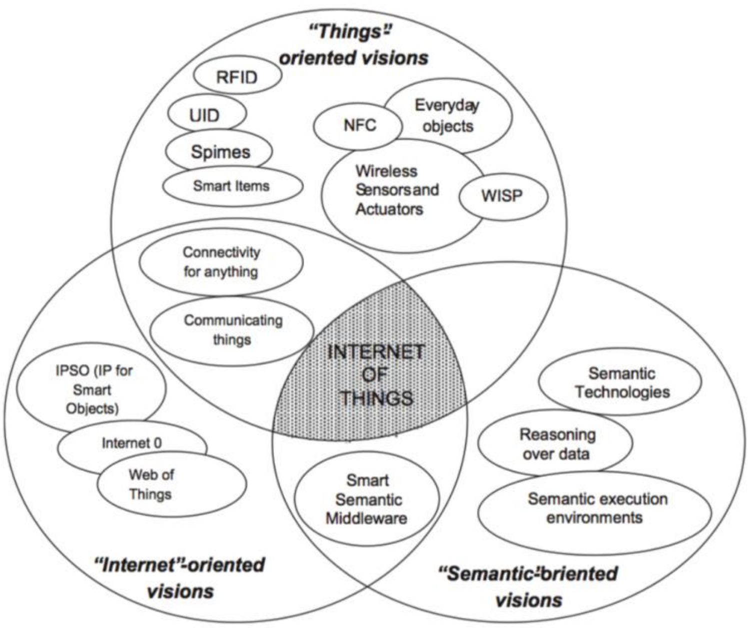

Figure 1: Internet of Things (Atzori et al., 2010, p. 2789)

2.2 Supply Chain Management

One of the trends which can be observed in supply chains is an increasing focus on agility. According to Christopher (2000, p.37) "Agility is a business-wide capability that embraces organisational structures, information systems, logistics processes, and, in particular, mindsets". One of the central characteristics of agile supply chains is their flexibility (Christopher, 2000, p.37), which makes agile Supply Chain Management a prerequisite in today's fast-developing business world. In the past, managers often focused on reducing supply chain costs, therefore accepting increased risks (Lee, 2008). In today's fast-moving and ever-changing economic and societal environment, risk management has become a topic of interest for many companies (Manuj and Mentzer, 2008). According to Lee (2008), supply chain risk management is designed to anticipate and prepare for disruptions, however there is no clear definition for supply chain risk management (Manuj and Mentzer, 2008).
Other trends comprise cooperative and collaborative concepts as well as an increased focus on supplier management (Storey et al., 2006, p.757). Generally, emerging trends in Supply Chain Management point towards a number of idealised supply management characteristics, namely "Seamless flow from initial source(s) to final customer", "Demand-led supply chain (only produce what is pulled through)", "Shared information across the whole chain (end to end pipeline visibility)", "Collaboration and partnership (mutual gains and added value for all; win-win; joint learning and joint design and development)", "IT enabled", "All products direct to shelf, Batch/ pack size configured to rate of sale", "Customer responsive", "Agile and lean", "Mass customisation" and "Market segmentation" (Storey et al., 2006, p.760).
In addition to the predominant organisational and strategic aspects discussed in literature, especially the two idealised characteristics of "Shared information across the whole chain" and "IT enabled" illustrate the importance of information technology for efficient supply chains.

Gartner Inc. (Pettey, 2018, Beadle, 2017) predicts 8 key supply chain technology trends. Among these trends are Blockchain, Immersive technologies, Robotic process automation and Internet of Things (IoT). Specifically named as a disruptive supply chain technology whose implications must be determined, Artificial Intelligence (AI) is expected to play a key role in transforming future supply chains (Pettey, 2018). A number of emerging AI technologies can also be found in the Gartner Hype Cycle for 2018 depicted in figure 2 (Panetta, 2018), e.g. Deep Learning and Conversational AI Platform.

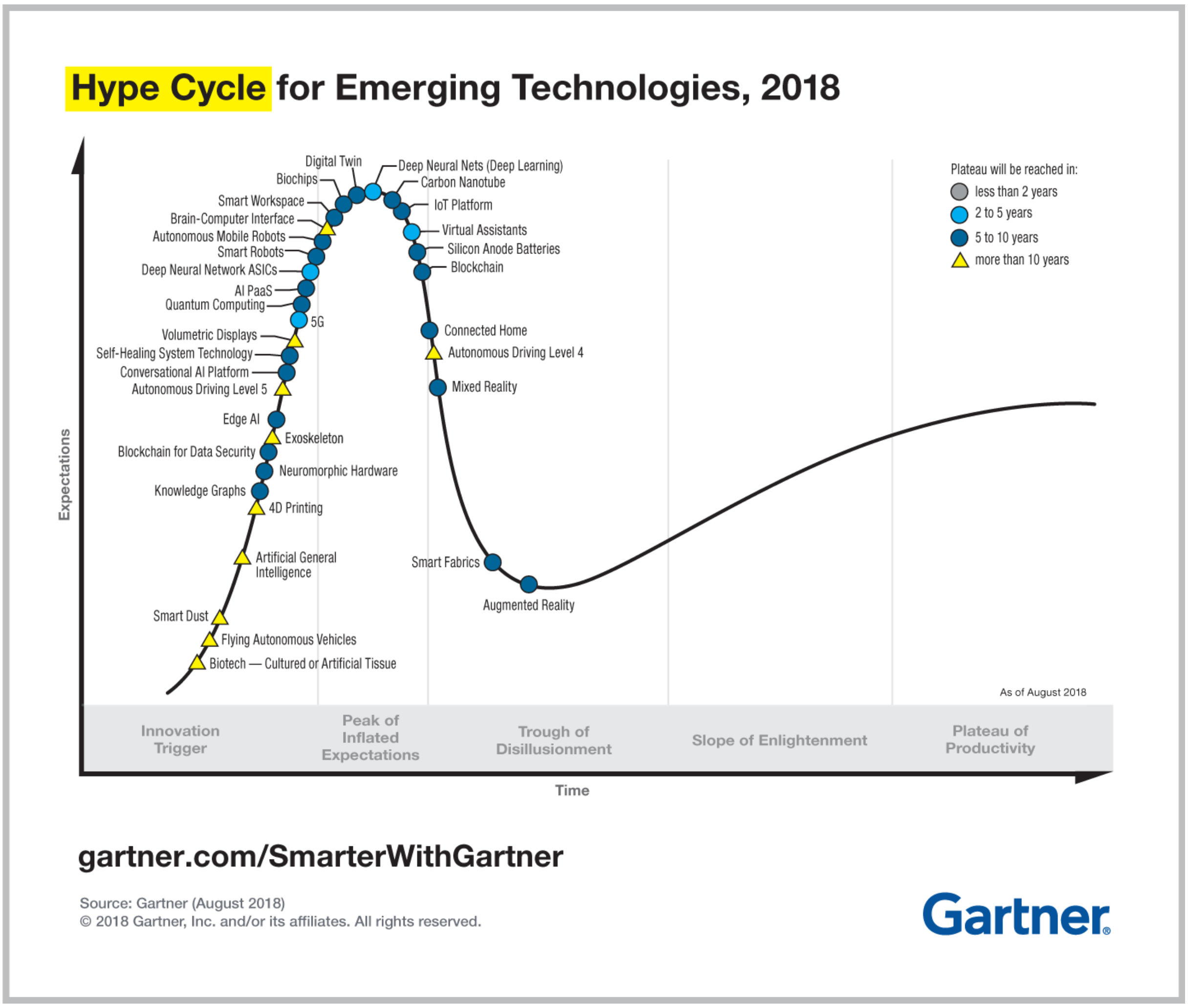

Figure 2: Gartner Hype Cycle for Emerging Technologies 2018 (Panetta, 2018)

According to the Cambridge Dictionary (n.d.), AI is "the study of how to produce machines that have some of the qualities that the human mind has, such as the ability to understand language, recognize pictures, solve problems, and learn". Luger (2009) identified the following 10 areas of general research and application: Game Playing, Automated Reasoning and Theorem Proving, Expert Systems, Natural Language Understanding and Semantics, Modelling Human Performance, Planning and Robotics, Languages and Environments for AI, Machine Learning, Alternative Representations (Neural Nets and Genetic Algorithms) and AI and Philosophy. AI tools can improve demand forecasting and planning by identifying patterns, as well as automate decision-making processes (Pettey, 2018).

In addition to the opportunities offered by this future-oriented technology, there will most likely be several challenges for companies in order to fully appreciate the benefits of automation etc. Firstly, readiness for change and adaptable structures are basic requirements for the integration of AI tools into strategic and operative business systems (Pettey, 2018). Gartner estimates that until the year 2021, "three out of five factory-level AI initiatives in large global companies will stall due to inadequate skill sets" (Beadle, 2017). In order to be effective, AI tools require complex human support, meaning that companies will need to employ specialists, e.g. for data ingestion. However, employees with these specific kinds of talent and skills are currently scarce and the required knowledge will have to be developed (Beadle, 2017). Moreover, complex decision-making such as strategic tasks such as network design or capacity planning still require human contribution (Pettey, 2018).

The necessity of the development of future-oriented technologies has also been acknowledged by governments. For instance, the German Federal Government has issued a strategy concerning research and development of AI, outlining numerous application-oriented uses: deduction systems and automated reasoning, knowledge-based systems, pattern analysis and recognition, robotics and intelligent multimodal Human-Machine-Interaction (FRG, 2018, p.5). The strategy paper also assumes that AI technology could optimise capacity planning and therefore reduce the number of empty runs, resulting in more environmentally-friendly transport (FRG, 2018, p.36).

2.3 Summary of State of the Art

Digitisation is omnipresent. It permeates all areas of social life, but in different ways. At present, it is mainly areas that can be relatively easily automated that are being digitally transformed. In order to be able to open up further areas that are relatively unstructured, very complex and usually associated with a relatively high use of human resources, Artificial Intelligence is required. Therefore, the first wave of digitisation is now overlaid by a second wave of AI technologies combined with further automation. In the future planning and design of production logistics systems and supply chains, this paradigm shift has to be considered strategically, tactically and operationally, especially for machine learning, growing computer performance and big data. (Manyika, 2019) Since the growing computing power has played a key role in digitisation for decades and will continue to be essential for the further maturity of the basic technologies and the applications based on them in the future, the development of quantum technology is of such outstanding importance. The expected leap in available computing power already today requires a new way of thinking with regard to the possibilities of digitising and automating applications even faster with the help of Artificial Intelligence. Quantum technology and AI are closely interrelated. On the one hand, AI is needed to better develop and master quantum technology. (Fösel et al, 2018) On the other hand, quantum technology will further push AI and its application. (Barnett, 2018)
The two sections covering the state of the art concerning future-oriented technologies in production logistics and Supply Chain Management have shown that there is still capacity for the implementation of innovative concepts. Although both areas have seen intensive development over the course of the last years, e.g. advances in automation, a need for further theoretical and practical development has been highlighted.

3 Research in Production Logistics and Supply Chain Management with Future-oriented Technologies

3.1 Production Logistics with an Interoperable Approach

Successful internal logistics are characterised by the challenges of adaptability, scalability, flexibility and shortened product lifecycles. In addition, it is becoming increasingly important to be able to respond to individual customer needs and react quickly. In order to support the processes and the reaction to the new framework conditions, there are various technological solutions and support available to respond to the individual application case. It is a particular challenge for growing and competitive companies to adapt the future technology to the respective application and industrial framework conditions. The integration and implementation of the new technology into the existing system and the networking of these new and existing systems is of particular importance. The trend and the necessity to an ever-higher degree of automation as well as the increasing heterogeneity of the system landscape pose great challenges for modern companies. The solution-oriented handling of the interfaces between the individual systems is particularly difficult in this context. Therefore, there will be an increased need in future to develop new solutions for the interface problem. With future-capable technologies, it will only be possible at great expense to create interfaces between different systems and to comply with the corresponding security aspects. In addition, the increasing integration of IT systems into complex and holistic production structures is a particular challenge. The interoperable approach of connecting different systems should provide support here. Interoperability plays a decisive but also critical role in the connection of future-oriented and heterogeneous technologies in interaction with the technical, administrative, and process-related influencing factors.

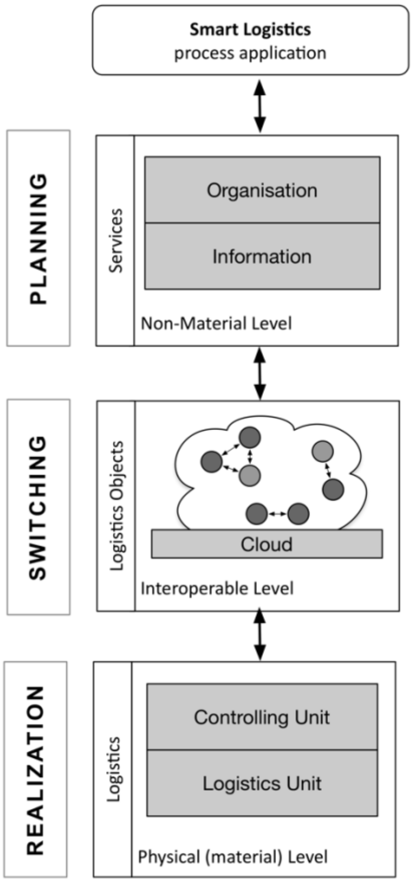

Figure 3: Interoperable Approach for Smart Logistics Services

Through an interoperable approach, complex systems and different system approaches as well as physical objects can be networked with each other, and thus also ensure communication across domain boundaries. The interoperable approach is characterised by five stages. At the simplest level 0, human intervention is necessary to achieve system interoperability. In level 1, physical data exchange is already possible. Level 2 is characterised by the exchange of information which can already be used meaningfully in a distributed environment. In level 3, semantic interoperability is already being pioneered. This creates domain-specific knowledge for shared use. However, this knowledge is only possible in the specific application area. This changes with level 4, in which the developed knowledge is available also beyond enterprise borders and in a universal access environment (Enterprise Interoperability).
The model shown in figure 3 shows an interoperable approach for smart logistics. Logistics acts as a service provider and provides logistics processes for the manufacturing company. The model is divided into three levels: planning, switching and realisation. In the planning level, the services for smart logistics are controlled. This level is also known as the non-material level. The services to be provided are divided into organisation and information logistics. In addition to the non-material level, there is also the physical, material level. In the model, this is referred

to as realisation. This level contains both the control unit and the physical logistics objects. The logistics objects provide the physical service in logistics. There is a third level as a link between the planning level and the realisation level. This is referred to as switching. It has the task of linking planning, that is, the service request, and the realisation, i.e. the physical execution of the logistics process. This is where the interoperable approach comes into play. This level controls the connection and communication of the logistics objects for the joint provision of the logistics service. Within the framework of this approach, special logistics objects (e.g. driverless transport systems, autonomous service robots) perform the execution of the physical process in a corresponding joint interaction. Since not every logistics object in a real factory environment has the same complexity and functional scope, this is represented in the model by the approach of different intelligence levels (see figure 4). The different functional scope and thus the smartness of the objects is expressed, for example, by different sensor, motor and actuator systems. Through the interoperable approach of the jointly acting logistic objects, their connection can thus be ensured via different functionalities and thus different smartness. The adapted approach of shells is used (VDI/VDE-GesellschaftZVEI - Zentralverband Elektrotechnik und Elektronikindustrie e.V., 2016).
In the sense of the differently existing smartness between the objects, a corresponding fusion of the model of the five interoperability levels is currently being researched. The next step, in a prototype research two AI robots will be connected with each other and the interoperable approach will be demonstrate. Thereby, the different smartness of the robots will be artificially programmed to the robots.

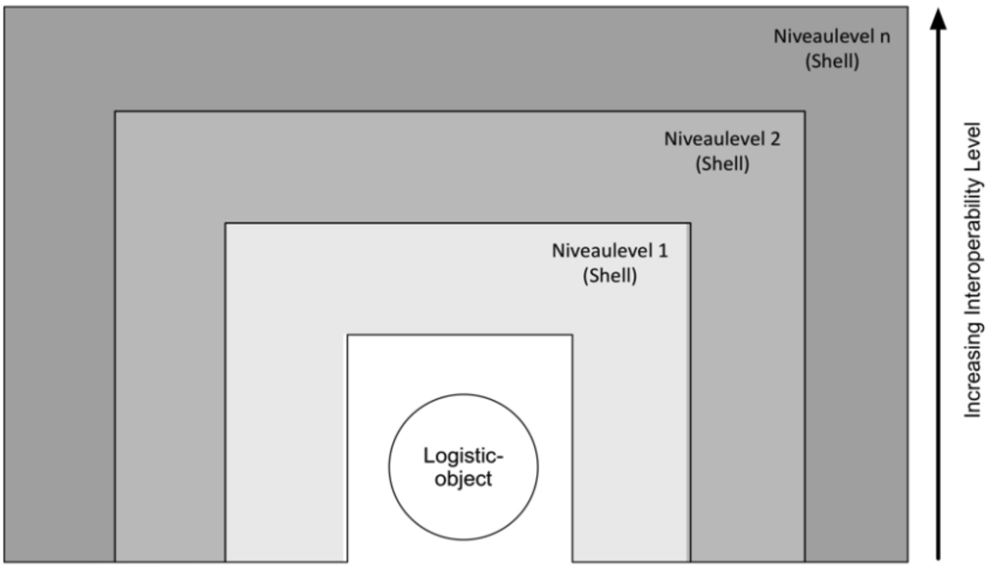

Figure 4: Increasing Interoperability Level by Approach of Shells

3.2 Supply Chain Management in Context of Artificial Intelligence

Creating and sustaining high performance supply networks in increasingly volatile business contexts is likely to require the implementation of future-oriented technologies. As mentioned before, AI is often regarded as one possible option to achieve more adaptable supply chain networks (Beadle, 2017, Pettey, 2018, Koutsojannis and Sirmakessis, 2009). According to the different AI features, AI can be classified into 4 sub-disciplines, see figure 5 (Min, 2009):

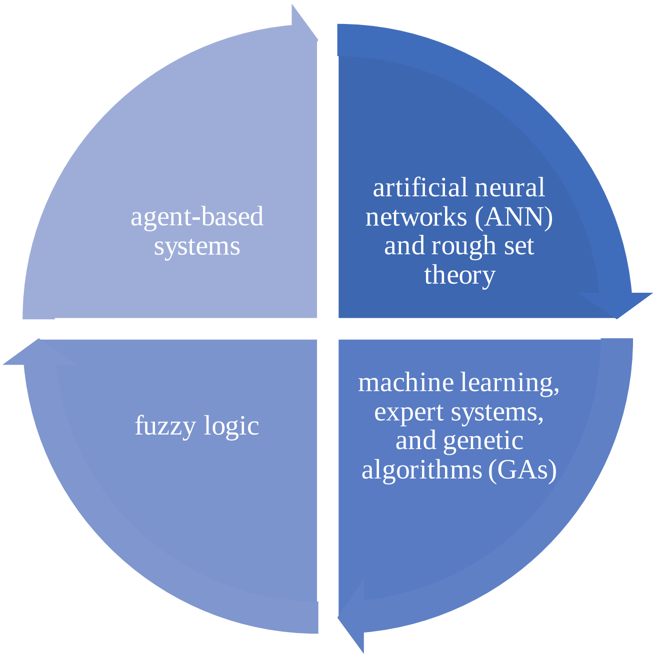

Figure 5: The 4 sub-disciplines of Artificial Intelligence (own adoption from Min, 2009)

Regarding the current status of AI use, Gesing et al. (2018, p.13) describe AI as currently applied as Narrow Intelligence (NI), "Dedicated to assist with or take over specific tasks". What is generally referred to as AI in the media and public discussion would be categorised as General AI ("systems with capabilities that equate to human intelligence") or Super AI ("Machines that are an order of magnitude smarter than humans"). They also found that about 60% of the corporations listed in the Forbes Global 2000 are carefully assessing possible AI applications or actively using it for specific business solutions (Gesing et al., 2018, p.13).

Concerning AI application in Supply Chain Management, Min (2009) found that the potential of AI application has not yet been explored to the full, after what Gesing et al. (2018) refer to as the second "AI winter". Some sub-fields of AI have already been applied to the Supply Chain context, namely expert systems and genetic algorithms (Min, 2009). This sub-discipline has specifically been used to address a wide range of issues related to SCM and logistics. The most commonly found areas of application were inventory management, purchasing processes, strategic location planning, freight consolidation and routing/scheduling problems (Min, 2009). Both Gesing et al. (2018) and Min (2009) argue that the potential of AI utilisation in SCM and logistics is currently not fully exploited and likely to expand in the years to come. It is said that the network-based nature of the logistics industry and supply chains in specific provide an ideal framework for AI implementation (Min, 2009).

In order to assess the current status of integration of future-oriented technology in Supply Chain Management we examined two examples.
The first case by Kimbrough et al. (2002) modelled an electronic supply chain managed by artificial agents (see above AI sub-field 4. agent-based systems). The aim of this investigation was to determine whether artificial agents could do better than humans at the MIT Beer Game. The MIT Beer Game requires a minimum of four players, which were replaced by artificial agents: Retailer, Wholesaler, Distributor, and Manufacturer. In the simple supply chain re-enacted in this game, the goal is to minimise long-term total supply chain inventory cost. Each agent affects its own and the other agents' inventory through placing orders at its immediate supplier. Naturally, each agent has to decide on individual order quantities depending on its own prediction regarding future demand quantities from its customer. Usually, when humans

play the beer game the result is the so-called bullwhip effect. The bullwhip effect can be characterised as “the variance of orders amplifies upstream in the supply chain” (Kimbrough et al., 2002). According to Kimbrough et al. (2002) there can be multiple reasons for this phenomenon, e.g. lack of incentives for information sharing, bounded rationality or individually rational behavior working against the best interest of the group. Figure 6 illustrates the Bullwhip effect using real data from a group of undergraduates playing the Beer Game during the study by Kimbrough et al. (2002).

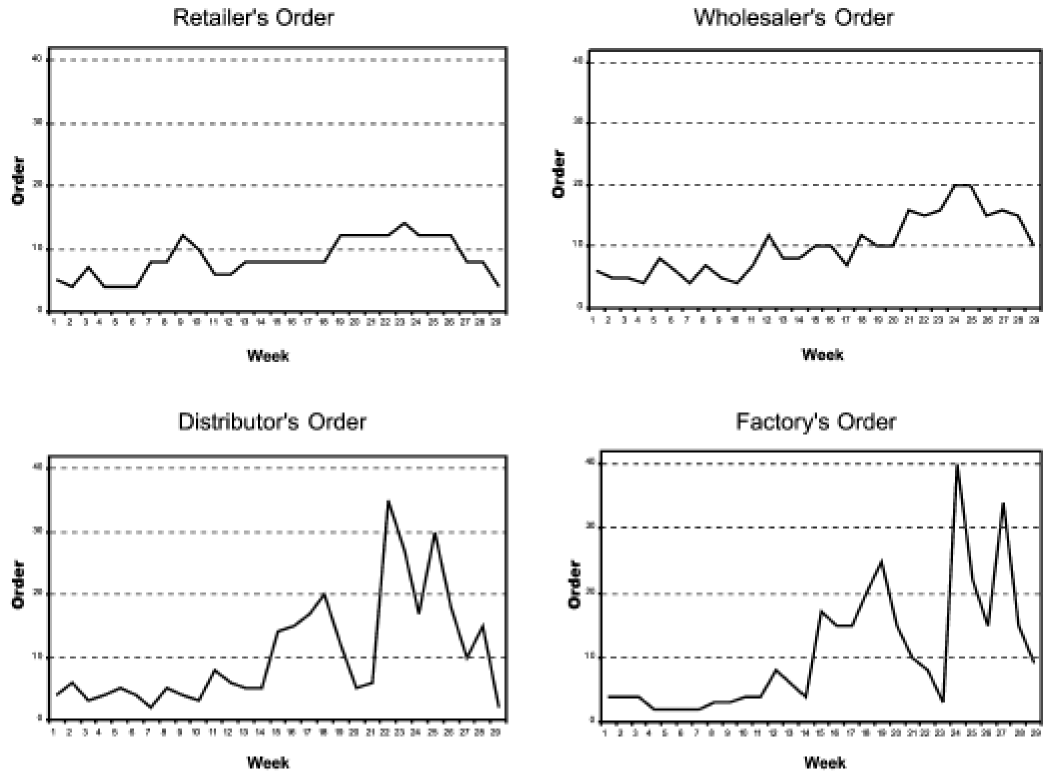

Figure 6: Bullwhip effect using real data from a group of undergraduates playing the Beer Game (Kimbrough et al., 2002, p.324)

The study by Kimbrough et al. (2002) found that artificial agents were able to effectively play the Beer Game. In the simulated adaptable and dynamic business environments, the agents were able to determine optimal order policies. From these experiments with simplified supply chain situations it could be derived that, when considering the accumulated cost of inventory over time, artificial agents out-performed human agents (see figure 7).

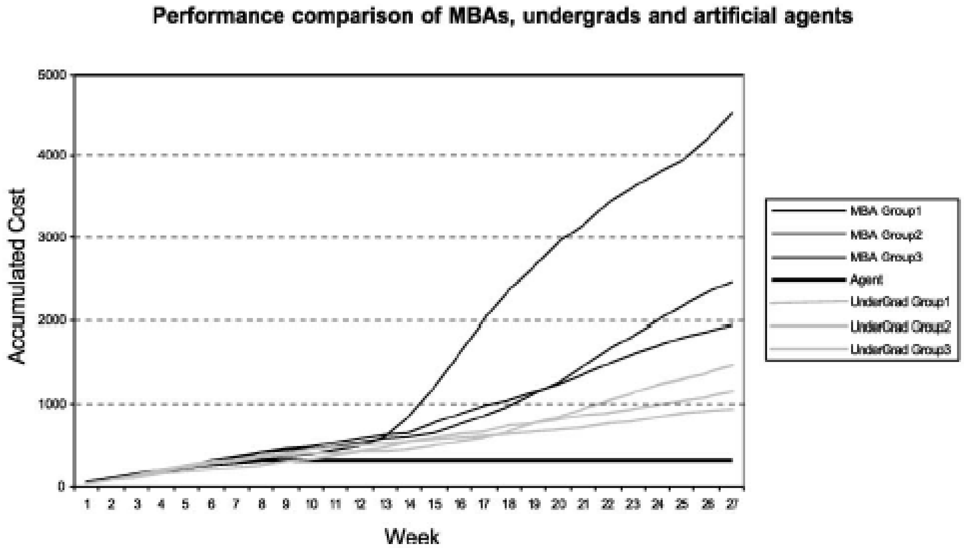

Figure 7: Artificial agents performance compared to MBA and undergraduate students in the MIT Beer Game (Kimbrough et al., 2002, p.328)

Some opportunities for real supply chain application can be drawn from this study. Firstly, it is possible that artificial agents would show less bounded rationality or individually rational behavior, resulting in better overall results. As a consquence, artificial agents could be used in well-organised supply chains in order to achieve lower total costs of inventory and more efficient order quantities. Possibly, this could also lead to a more balanced and equal positioning of supply chain agents. If trained correctly for more complicated supply chains, the agents could allow for better forecasting when traditional analytical methods not available.
However, the integration of artificial agents could also present challenges. For example, these computer programs need to be trained extensively for the intended application situation. Also, the duration until the artificial agents find the optimal order policies was found to increase depending on the number of agents introduced to the system, which could affect decision-making processes (Kimbrough et al., 2002).

The second case covers the application of AI for Supply Chain Risk Management, more specifically Predictive Risk Management. This case falls into second the sub-discipline mentioned above, machine learning. DHL is a mail and logistics company operating internationally. In order to manage supply chain risk DHL developed the Resilience360 platform, a cloud-based solution designed for global logistics operators (Gesing et al., 2018). As complex international supply chain sometimes comprise thousands of suppliers, they are subject to numerous impact factors and daily disruptions.
The Tool consists of four separate products: Supply Chain Visualisation, Risk Assessment, Incident Monitoring and Risk Response (Anon, n.d.). The Resilience360 platform and the Supply Watch module integrate AI technology by utilising machine learning and natural language processing techniques (Gesing et al., 2018). Essentially, the Supply Watch constantly monitors online and social media sources and analyses the content and context of unstructured online texts (Gesing et al., 2018). Through machine learning and language processing the tool is able to understand sentiment and identify risk indicators, thus enabling swift corrective or even preventive action (Gesing et al., 2018).
Clear opportunities from this kind of AI application are the prevention of supply chain disruptions and consequently cost savings. Additionally, the visualisation and general risk assessment can help organisation to better understand the processes involved and to subsequently improve supply chain organisation and management.
On the other hand, current AI risk assessment does not possess human intuition and might therefore misinterpret unstructured texts, resulting in unnecessary or wrong action advice.

However, as the Resilience360 platform is operated by humans and the AI components are only used to to identify supplier-side risks and not immediately initiate action, this risk is eliminated (Gesing et al., 2018).

As illustrated by these two cases, AI is being used effectively for individual company-specific situations, but generally the utilisation probably remains below the possibilities. However, the different sub-disciplines and tools of AI can offer businesses attractive solutions for a wide variety of issues ranging from Supply Chain Risk Management to Predictive Maintenance or routing optimisation. Clearly, this future-oriented technology can present both benefits and dangers and more intensive research into AI integration possibilities in SCM and their respective consequences is needed.

4 Conclusion

In summary, it can be stated that, triggered by the all-encompassing digitisation, great innovation potentials can be achieved through AI, machine learning and related technologies. Selected examples are augmented real-time decision making, predictive analysis, and strategic optimisation. (Penske, 2018) Interoperability in connection with future technologies for logistics means, that in addition to automation, the new possibilities in the cognitive field based on AI are also sufficiently considered. It refers not only to the technical infrastructure and equipment, but also to the soft factors such as knowledge transfer and competence development, planning and control, etc. of logistics systems. The strategic orientation of the companies with regard to their logistics competence should follow this trend, because otherwise massive competitive disadvantages could arise. The growing maturity of digitisation in the context of automation and AI will be reflected in higher computing power, for example through quantum technology, in continuous and destructive innovations in logistics. It will influence the further development of SCM and logistics. Megatrends are the digitisation of the supply chain and the application of AI for these application areas, on which closer cooperation, risk control and resilience, knowledge-based systems, circular supply chain, wearable technologies and service orientation are based. Transparency and visibility, etc. can be developed. (A & A Customs Brokers, n.d.). Moreover, production logistics and SCM peripheral areas are affected by these changes. They concern intelligent and automated warehouses, logistic applications of blockchain technology, smart traffic systems, autonomous driving, vehicle telematics, etc. (Peters, 2018)

This paper showed which opportunities and challenges could arise from the implementation of future-oriented technologies in production logistics and Supply Chain Management. Overall, the specific use cases and models introduced have illustrated the advantages enabled through technological advancements. However, potential dangers must be considered and we should thrive for a comprehensive societal approach to new live-changing concepts such as digitisation.

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