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The Application of Digital Technologies in Supply Chain Management

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Abstract

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Today, companies are increasingly stressing the roles of supply chain management and digitalization to enhance the whole business. The role of supply chain management is getting stronger and more strategic in terms of value creation while various digital solutions contribute to this development. In this thesis, the past, present and future views of digitalization in supply chains will be discussed, and also the reasons why digitalization strategies fail and how they could be managed. In addition, there will be discussion on five technologies: data analytics, Internet of Things, artificial intelligence, cloud computing and blockchain. Of all these technologies, the benefits, challenges and future developments are presented from the supply chain management's point of view. The empirical section was conducted by interviewing five companies from five different industries of which one was the provider of digital solutions and the rest were the users of digital technologies or companies with vast supply chains. The objectives of the interviews were to compare the level of digitalization in the supply chain management to the other departments, determine what kind of digital technologies they are currently using or are about to implement, and map the experienced challenges and benefits of these technologies. By conducting this study, it was found that digital technologies can significantly improve the processes of supply chains in many unique ways. Despite this, the interviewed companies were not yet using all of the technologies in a broad scale.

Tiivistelmä

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Yritykset huomioivat yhä enemmän hankintatoimen ja digitalisaation roolia koko liiketoiminnan kehittämisessä. Hankintatoimen rooli on muuttumassa vahvemmaksi ja strategisemmaksi arvon luonnin kannalta, ja digitaaliset työkalut edesauttavat tätä kehitystä. Tässä tutkimuksessa käsitellään digitalisaation yleistä roolia hankintatoimessa niin menneisyyden, nykyisyyden kuin tulevaisuudenkin kannalta sekä sitä, mitä ongelmia siihen liittyy ja miten niitä voidaan ratkaista. Lisäksi käsitellään viittä eri teknologiaa: data-analytiikkaa, esineiden internetiä, tekoälyä, pilvipalveluita ja lohkoketjuteknologiaa. Näistä kaikista teknologioista esitellään useita hyötyjä, haittoja ja tulevaisuuden näkymiä hankintatoimen näkökulmasta. Tutkimuksen empiirinen osuus toteutettiin haastatteleamalla viittä eri toimialaa edustavaa suuryritystä, joista yksi oli digitaalisten teknologioiden tarjoaja ja loput niiden käyttäjiä tai muuten laajan hankintaorganisaation omaavia yrityksiä. Haastatteluissa kartoitettiin muun muassa heidän digitalisaation tasoa koko yrityksessä ja vertailtiin sitä hankintatoimeen, millaisia digitaalisia teknologioita he käyttävät tai aikovat ottaa käyttöön sekä niistä koettuja hyötyjä ja haasteita. Tutkimuksessa selvisi, että digitaalisten teknologioiden käytöllä voidaan huomattavasti parantaa hankintatoimen prosesseja monella eri tavalla, mutta siitä huolimatta tutkimukseen osallistuneet yritykset eivät keskimäärin käyttäneet niitä vielä laajassa mittakaavassa.

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Writing this thesis taught a great thing about modern digital technologies and being patient. I actually thought that this thesis would be a big task, but the rumors proved to be exaggerated just as with the bachelor's thesis. Honestly, the only tough part of this process was to keep writing the same text consecutively for three months without getting any variation in work. These said, a word for those about to start their master's thesis: do not waste your time stressing because the writing process will not be that difficult. It helps a lot if the topic really interests you in any way since then you actually want to learn about the things you write.

I would like to thank my girlfriend for helping with this whole process due to her participation on checking the grammar and fluency of the text, but also her constant encouragement to keep me working on this thesis. The first supervisor helped with this process by giving his endorsement on this topic and providing a good tip regarding who to interview for the empirical section. The biggest thanks, however, belong to all the five interviewees who kindly agreed to participate in this study because without them this would not have been possible. They also provided plenty of information and tips which were really helpful in doing this thesis.

Three years ago, it felt good to be accepted to LUT but now it feels even better to leave it.

Olli Lehtisalo

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1 Introduction

In the current, highly competitive markets, it is crucial for companies to innovate new ways of streamlining their supply chains and optimizing productivity. In addition to that, customer expectations are changing: individualization is growing, which means that customers desire higher service expectations together with more customized orders, and this forces companies to create new solutions to cope with these changing requirements. By integrating modern technologies into businesses, companies can significantly enhance their productivity while at the same time cut costs and improve customer satisfaction and client retention due to more stable and efficient supply chains. In addition, technologies create more transparent and simplified supply chains, which enables business executives to have a better control over their business operations in general. In other words, digital technologies can offer companies a great competitive edge over their competitors. (Alicke, Rexhausen and Seyfert 2017; FlashGlobal 2018)

Bughin, Catlin, Hirt and Willmott (2018) point out that there are many digital technologies emerging capable of improving the supply chain management, such as Big Data, Internet of Things, blockchain, cloud, artificial intelligence, machine learning and many more applications. What combines all these digital technologies, is that they offer various opportunities to enhance supply chain operations in their own ways. For example, robotic process automation has digitized 50-80 % of back-office processes in many industries. Artificial intelligence can raise both the manufacturing profits and quality. Blockchain is able to revolutionize complex and paper-intensive processes, with successful applications already starting to emerge in many industries, e.g. in financial industry. Alicke et al. (2017) in turn expect that digital technologies will in the next few years lower the operational costs by 30 % and reduce lost sales and inventories by up to 75 %. At the same time, they will bring more agility to supply chains.

Digital technologies are nowadays important tools to sustain viable alliances and create value networks with other companies and actors since in the complex digital market it is nearly impossible to succeed or deliver sufficient service to customers without them (Barnes 2002). In addition, digital technologies are transforming the structure of social partnerships

from both the companies' and customers' points of view, and products and services have increasingly embedded them. Therefore, it is constantly harder to separate business operations from their information technology infrastructures. (Orlikowski 1992; El Sawy 2003) It can be said that digital technologies are crucial for businesses if they desire to succeed in the future.

Much has been studied about the lack of digital technology's utilization in global context but not about how the situation is in Finland. Also, many studies have been conducted mainly concerning the B2C markets' use of digitalization, while B2B markets are much less analyzed (Pagani and Pardo 2017). These are the reasons why this thesis mainly focuses on the companies operating in B2B markets. Furthermore, B2B companies are constantly being transformed by digital technologies because those companies can access a wide range of technologies that allow to them to manage interaction between multiple partners across the network (Richard and Devinney 2005). The significance of B2B digitization and its competitive benefits can easily be overlooked since the current digital changes are harder to notice instantly than those in B2C markets. Despite this, B2B companies can also be disruptive since it has been a growing trend during the past few years that those companies have digitized their core offerings and operations more sufficiently than B2C companies. Furthermore, digitizing B2B companies are both improving the reach and quality, but also lowering the costs of their offerings. (Bughin et al. 2018)

The term *supply chain management* will be used frequently in this thesis. Supply Chain Resource Cooperative (2017) describes it briefly: *Supply chain management (SCM) is the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. It represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective & efficient ways possible. Supply chain activities cover everything from product development, sourcing, production, and logistics, as well as the information systems needed to coordinate these activities.*

The objective of this thesis is to determine the overall situation of digitalization in supply chain management (SCM), how to manage digital transformation, what kind of digital technologies could be used in SCM, what the benefits and challenges of these technologies are, and how real-life companies use them and feel about the digitalization in their SCM

departments. Lastly the aim is to connect these theory and empirical findings together and analyze them.

The structure of this thesis goes as follows: first comes the research questions of this study. After this begins the theory part, which starts with a general discussion about digitalization in companies and supply chains, for instance, what are the difficulties of digitalization and what companies can do to drive its growth. The second part of the theory section focuses on five digital technologies and how they can be used in supply chain management. When the theory part is over, the empirical section begins in which five companies are interviewed about their usage of and views on these digital technologies. The last sections of this thesis are the discussion and conclusion parts where the findings from the theory and empirical sections will be summarized and analyzed with the help of the research questions. The conclusion part includes also the limitations of this study, future research topics and recommendations on how this study could be helpful for real-life situations.

1.1 Research questions

In this section, the research questions will be presented. This thesis answers two main research questions and they are as follows:

What kind of major digital technologies have recently emerged or are about to emerge in the near future?

Do companies in different industries use these digital technologies in their supply chains, and if so, in what ways?

Information for the first question will be presented and discussed in more detail in chapters 2 and 3. Also, all the technologies that are found are related to supply chain management. The term *recently* is hard to define exactly since many of the technologies are born gradually and the originality is hard to trace back. Furthermore, some technologies have existed for decades but only during the past few years they have gained popularity among the business industry. Therefore, technologies emerged in the business industry within 10 years would be a good guideline. For the second question, data will mainly be gathered by interviewing

different companies operating in different industries, and the results will be discussed in the empirical part, chapter 4. Some information will be discussed also in chapters 2 and 3 but the main focus is on chapter 4. All the questions will be analyzed more comprehensively and combined together in the discussion part, chapter 5.

In addition to the main research questions, there are also three sub questions to gain a thorough understanding of the context of digital technologies among supply chains. The purpose of them are to supplement the

What are the benefits, challenges and views of future of these technologies?

If the technologies have not been used yet, what is the reason for that?

How can companies manage digitalization?

Answers to the first sub-question will be gathered in chapters 2 and 3, but also in chapter 4 where the empirical findings will support the findings. The second sub-question is mainly for the empirical part where the companies will tell the reasons for not using a certain technology. Theory about this topic will be discussed in chapter 2, and thus, the findings from these two chapters will also be combined in chapter 5. The third sub-question is heavily based on the information found on chapter 2 and the findings are then reflected to the empirical findings in chapter 4.

2 Digitalization in supply chains

Before discussing *digitalization*, it is necessary to define the term and differentiate it from the other terms, *digitization* and *digital transformation*, which are often confused with each other. When regarding for instance the digital technologies of a company, the three terms actually form a pattern of progress: first comes digitization, then digitalization and finally the digital transforming. (Coresystems 2018)

Digitization means that the company transits all of its available and accessible data into a digital format. In other words, it means companies getting rid of paper documents and inputting them to a computer or some other digital platform. When all the information has been digitized, it is time for the digitalization process, which means the information is being used properly for the benefit of the company to create more value. For example, centralized data about customers' contact information and product history helps the company to stay informed about the previous issues of their customers and what types of problems they encounter. This is the reason why digitalization requires expertise on how to utilize the digitized information and create applications that provide the right tools for adding value. After the digitalization, all the information and data are easily available, and it is time to create entirely new business models through digital transformation. It is the process of inventing new business applications that integrate all the digitized data and digitalized applications and thus, it has the power to improve productivity also across the supply chains. Digital transformation technologies are capable in helping businesses to redefine their work methods by integrating external market connections with internal digital processes. Netflix is a well-known example of a company utilizing all of these three steps, since it was one of the first companies in online movie streaming industry that first required movies to be digitized and data digitalized in order to create a smooth streaming experience. (Coresystems 2018; Gartner 2018; IDC 2017)

The importance of information and communication technology (ICT) to different companies operating in various industries has long been acknowledged. In these traditional approaches, information and communication technology has been seen as technological tools in several service delivery processes. These kinds of approaches have led to an increase of efficiency and productivity in many companies which may lead to completely new markets. However,

the same technologies do not fit to all industries' needs and structures, but this will probably change over time (Barras 1986 & 1990; Abood and Quilligan 2018).

During the past decade, the focus has been increasing towards services coupled with transformational developments in information and communication technologies, and they are generating great opportunities in the field of service and products innovations. This is one reason why businesses across the globe have started to embrace digital technologies as their engines of growth. Furthermore, digitalization enables easier access to services that are superior to products in terms of availability with fewer resources. This naturally eases both the company and the customer to benefit from new opportunities brought from modern technologies. A good example of this is the M-Pesa money transfer service that enabled millions of Africans left outside of the financial system to access financial services via mobile infrastructure. This way they did not need to build any expensive infrastructure to offer an access to these systems. (Barrett, Davidson, Prabhu and Vargo 2015; Spohrer and Maglio 2010)

Digitalization is not always an easy process and the possibilities it brings can sometimes be unknown to many business executives. According to Lindgren (2015) one of the most important requirements to reach a successful change is the courage to abandon legacy operating models, keep an open mind and think about the future without any presumptions. Also, digitalization should not be seen just as an update of the current business model, but instead, it is the key factor enabling whole new operating models. He also mentions that there are three major ways in which digitalization is changing companies' business models all around the world: operating environment, customer service and new business opportunities. The next few chapters will refer Lindgren's (2015) article excluding the other references mentioned in them.

Operating environment is changing due to the various new ecosystems, and it is important to allow a smooth collaboration and information sharing between them. It is crucial that the solutions are also safe, easy to use, cost-effective and simple to maintain. This way, digitalization can help companies to increase both their productivity and efficiency. When they create totally new solutions, they can simplify their basic information technology (IT)

and run it more cost-effectively. If doing so, the saved resources can be channeled into something else and more productive.

There are different views on what the role of supply chain is within companies, which leads to different approaches when considering digital technologies. Usually, technology has been seen as a solution to develop companies' inner functions, such as increasing productivity, streamlining processes and automating supply chains. According to Accenture (2018) only 48 % of supply chain executives consider the supply chain as a competitive differentiator, 68 % are still seeing it just as a support role, and 60 % are mainly concerned about driving cost efficiencies. Luckily though, 53 % currently see the supply chain a way to grow the business.

Digitalization in supply chains can help companies in many ways, for instance, it can make especially customer service excel if done correctly. Changing consumer behavior and the development of new versatile technologies have switched the focus towards improving customer service and personalizing customer experience. A major advantage of digitalization is that it makes possible to get closer to the customer and even help them before they realize they need it in the first place. This is achieved by analyzing customer data, which in turn gives a better understanding of the customer base. A great example of predicting customers' needs are the online stores, like Amazon, that recommend products to its customers according to the data gathered from them and analyzed with recommendation engines (Amazon Webservices 2018a). Furthermore, some online clothing companies gather information about their customers' measurements, which allows new customers to estimate their measures just by inserting their weight, height and body type (Tailorstore 2018). The same trend can also be seen in the more old-fashioned and traditional B2B industrial markets: Konecranes (2018) utilizes industrial internet and IoT to detect and prevent faults in their machines, even before they emerge. By predicting the customers' future needs, companies have more time to prepare their operations regarding the needs, and thus, prevent major faults or shortages from happening.

As aforementioned, digitalization can create countless of new business opportunities because it enables digital transformation and therefore it indirectly allows companies to run their businesses in completely new ways. One good example of a whole new business

industry is the sharing economy, like Airbnb and bike sharing applications, which would not exist without digitalization. During the digital era, most of the successful ideas are invented by an external party since they do not have existing burdens, like bureaucracy, to slow the evolving process. However, many companies may be surprised to see how lucrative their current innovative culture actually is, and these ideas can easily be brought into life with digital tools and the right strategies. For instance, internal innovation processes that constantly gather ideas from every employee starting from the grass-root level, have the opportunity to create great innovations. Of course, this is possible to do without digitalization, but digital technology makes the task much easier and cost-effective.

Despite the many opportunities of digital technologies, many companies are still not investing in them properly and a majority of companies' revenues still come from traditional sources. McKinsey & Company (2017) conducted a survey, which indicated vast differences between industries in terms of their level of digitization, and that companies feel threatened by the pressure of digital technologies. On average, one third of the revenue was mentioned to be lost during the next few years if the companies took no further actions to address the digital pressure and competition coming from digitally more advanced competitors. The level of digitization between different industries varied a lot: consumer packaged goods had only ca. 12 % degree of digitization, whereas the level of digitization of high tech reached even 40 %. Other high degrees were in media and entertainment (36 %), other financial services (32 %), and telecommunications (30 %). In addition to high degrees of digitization, these highest-ranking industries had other similarities: they all had the biggest portions (ca. 40 %) of revenues at risk because of digital pressure. Other industries with low degrees of digitization were insurance (20 %), automotive and assembly (18 %), and retail (18 %). Similarly, these companies had the lowest amount of revenues at risk because of digital pressure. The survey also indicated that the bigger the market share a company had, the more revenue was relatively at risk.

The survey noted that digital technology clearly benefits companies. McKinsey (2017) divided the respondents into four different categories depending on their digital approach: digital natives, incumbents competing in new ways through digitization, incumbents competing in new industries through digital moves and initiatives, and incumbents

competing mostly in ordinary, nondigital ways. Responses from the first three groups show that all those companies outperformed their traditional-incumbent peers in terms of earnings.

Moreover, many companies are putting much effort into the improvement of their supply chains but the amount of digital technologies being used is fairly low. According to Gezgin, Huang, Samal and Silva (2017) supply chains have only an average of 43 % level of digitization in the lowest section of firms studied. Also, 98 % of companies are saying that supply chains are not their primary targets of digital strategies, even though it is estimated that those companies aggressively digitizing their supply chains are able to increase their EBIT by up to 3,2 % and annual revenue by 2,3 %. Other reasons for the lack of use of digital technologies in supply chain management are discussed in chapter 2.1.

Alicke et al. (2017) predict that digital technologies in general, have the opportunity to affect the future of supply chain management drastically. Digitization of supply chains will lead to many advantages, such as them becoming faster, more flexible, granular, accurate and efficient. Supply chains become faster because of the highly developed forecasting methods, like predictive analytics that can analyze both external and internal data, which allow to predict the customers' needs efficiently. Amazon is a good example of a trailblazer in this context since they currently own a patent for "predictive shipping", meaning that they can ship the goods even before the customer orders anything. Flexibility, on the other hand, can be achieved by real-time planning that enables quicker responds to changes in either demand or supply, thus minimizing planning cycles and frozen periods. Flexibility also means that companies can more easily buy supply chain operations as a service from external companies or service providers. The flexibility reaches all the way to the transport industry since it becomes crowdsourced and more flexible. This creates manufacturers an opportunity to enter direct-to-consumers market that previously has been mainly occupied by retailers.

Due to customers desiring for more individualized products, companies need to manage this demand at a more granular level by using various different techniques, for instance micro segmentation, mass customization and sophisticated scheduling approaches. Drones are seen as one solution to this because they allow quicker deliveries for various types of packages and for various types of customers. Digital technologies make supply chains more accurate because they bring real-time information and end-to-end transparency to the whole supply

chain. For instance, cloud-based technologies combine all stakeholders under the same systems and thus, allowing everyone to see the current location of commodities and required key performance indicators, which leads to coherent ways of working. Moreover, technologies will be able to automatically identify threats or exceptions occurring somewhere in the supply chain, and can also react to these changes, all without a human involvement. This results supply chains to constantly push towards their optimized and most efficient objective. Robots and automation are also playing a vital role in the efficiency creation in supply chains since they can handle the logistics of physical goods faster than human labor. In summary, by adopting new technologies, companies are able to create a huge lever to enhance the operational effectiveness of their supply chains, and these examples are just a scratch on the surface when considering the possibilities digital technologies bring. (Alicke et al. 2017)

Digitalization will change the future massively if it is assumed that the historical development will continue due to the rapid growth of technology-based companies. For example, since the year 2000 approximately half of Fortune 500 companies have disappeared from the list, and these traditional asset heavy companies have mainly been replaced by newer technology-based companies. In 2000 Microsoft was the only technology company in the top five companies in this list in terms of market capitalization. By 2016, all the five biggest companies were technology-based, such as Alphabet and Apple. Also, when considering the S&P 500 list in 1975, around 83 percent of the valuation of these companies consisted of tangible assets, and in 2015 the portion was only 13 percent. At the same time, the value of intangible assets rose from 17 percent to 87 percent. (Teigland, Bogusz and Felländer 2017, 301)

2.1 Reasons why digitalization and digital transformation strategies fail

“Imagine that you are an executive responsible for digital strategies in a big company. You have a 250 square meter house in Westend, three children with expensive hobbies and a summer cottage with a big yacht. Would you risk your current high salary and bonuses for implementing new digital strategies that are not by any means guaranteed to succeed?” This quotation is from an interview with Antti Merilehto (2018) who is the author of recently published book, *Tekoäly – matkaopas johtajalle*. The quotation gives an image of what many

business executives face when they are managing digital strategies, and it is one of the many reasons why those strategies fail, or even worse, never see the daylight. Furthermore, the biggest impediment to digital success according to Harvey Nash Group and KPMG (2017) is the resistance to change with 43 percent of companies' chief information officers being of that opinion. These imply the fact that technological advances need motivated and open-minded people because with people resisting the change, nothing can happen.

Digital technologies are considered as high-stakes game where the rewards for success can be enormous, while a failure can lead to drastic losses, even bankruptcies (Arora, Dahlström, Groover and Wunderlich 2017). Despite the vast opportunities of digitalization, it is not always that easy to utilize it. Harvey Nash Group and KPMG (2017, 8) conducted a survey for 4498 chief information officers in 86 countries, and the results indicated that 88 % of them felt that their businesses are yet to fully benefit from their digital strategies. Furthermore, according to D'Emidio, Dorton & Duncan (2015) especially big companies seldom put as much resources into the transformation process of services as they put in product development. This is mainly because change is difficult to put into practice when a company has heavy legacy systems optimized to work a specific way, and when the staff owns wrong kinds of working approaches and methods. The slow approach many companies choose to improve their service portfolio does not help because processes that grind out small, constant cost deductions will usually not provide any major breakthroughs.

As previously mentioned, the level of digitization in supply chains is low in many industries and companies. Gezgin et al. (2017) say that the main reason behind this can be the cause of management choices and gaps in technology. Technology gaps occur when the advances and improvement factors of digital technologies vanish quickly after implementing them the first few times. This kind of trend favors the more simplified technologies that are meant to streamline everyday processes, expand the capabilities of certain systems and improve the analytical approaches. Of course, these technologies help enhance the functionality of supply chains, but they do not transform supply chain management. Luckily, better digital technologies are gradually becoming accessible easier, and they allow greater improvements than before. However, companies are still not able to benefit from them because they often overlook operational changes that help them to take a full advantage of digital technologies. Also, companies need to make complementary technological improvements in other

processes as well because one solution does not function without the other counterparts also being digitized properly. For example, a healthcare company tried to fix its weakening supply chain by upgrading its ERP system. However, this did not help to enhance the supply chain because their demand forecasting methods were not able to provide enough support for the new ERP. When they upgraded the both of them, they were finally able to enhance their supply chain. Other example is a consumer-based company that managed to improve its supply chains by conducting multiple operational changes, but soon they reverted to the starting point. This happened because the existing older technologies were not capable of supporting the new operations.

According to Wipro Digital (2017), digital transformation can also be very difficult to accomplish. They conducted a study where they surveyed 400 senior-level U.S.-based business executives about their digital transformation strategies within their organizations. The findings of this study identified a few leadership issues as the key factors that complicate the digital transformation. The first finding was that 91 % of the executives of companies understand the meaning of digital transformation in theory, but not in practice, and a third of them cited that they lack a clear transformation strategy. Bughin, Catlin, Hirt and Willmott (2018) have also noted that leaders often lack a thorough understanding of the term digitalization since they have different views on the meaning, for example some think it as an upgrade for their current IT function while others think digitalization only refers to marketing department. This lack of a clear definition of digitalization makes it harder to connect digital strategies to their companies' businesses.

The second finding from Wipro Digital's (2017) study was that 20 % of executives think that digital transformation projects are a waste of time and resources in their company. The third finding was that the leadership's mindsets and skills propose a challenge: chief executive officers, chief technology officers and chief information officers are most likely the primary drivers behind these strategies and they are twice as likely to take this role than other senior executives. Yet they say that resistance towards introducing new ways of working and feeling overwhelmed by the complexity of digitalization are the top two difficulties preventing the companies from achieving their full digital potential. The fourth finding was that the distribution of benefits is not evenly distributed within companies because back-end departments, such as procurement, finance and IT, are benefitting the most

from digital transformation, whereas the front-end departments, like marketing and sales, gain hardly any benefits from this. The fifth finding was that chief marketing officers are constantly spending more money on IT, but despite this they are hardly ever (in 2 % of cases) driving the digital strategies. Another surprising fact was that in only 12 % of cases the chief digital officers are driving the strategies. This fifth finding correlates well with the fact that 25 % of executives say the structure of their company has not changed to reflect the needs of digitalization. The last finding was that 50 % of executives believe that their companies are not able to execute half of their strategies at all. Furthermore, only 4 % realize half of their digital investments in less than one year, when majority says it has taken 2-3 years to see at least half of those investments to create any profit.

Companies can sometimes find themselves operating in the wrong market and/or in the wrong time regarding digital strategies. Digital competition lowers the value companies gain because digitalization allows many new companies to operate at lower costs and therefore offer their services at lower prices. A good example is the ridesharing service Über, which provides approximately 40 % cheaper car rides than regular taxis in the area of Los Angeles. When it comes to other financial metrics, the return of investment also differentiates between different companies depending on their approach to digital solutions: those who do business in new markets or operate with new digital solutions, have an average of 12 % return of investment, and those who invest in digital solutions to protect their core business have only 6 % return of investment. Also, digital competition makes the revenue distribution and growth amongst companies utilizing digital technologies vary notably. Only the top 25 % of companies are increasing their profits with digitalization and the rest 75 % are losing twice as much money compared to the highest quartile. However, digitalization does not always benefit the companies, since digital technology can even sometimes create more value for the customers than for companies. One reason for the lower value of companies is that digital technologies often allow customers to choose only the services or products they are actually willing to pay for, and that way the digital services prevent companies to cash from any profitable extra additions. (Bughin, Catlin, Hirt and Willmott 2018)

The survey of Harvey Nash Group and KPMG (2017, 4-5) shows that the shortage of competent employees in the field of digital technologies is a common problem when considering the implementation and effectiveness of digital technologies, since 60 % of chief

information officers report that they constantly face lacking technology skills. Also, there are three major skills that were the hardest to find from the employers' point of view: big data/analytics was mentioned by 42 %, especially by large companies. Business analytics was mentioned by 34 %, mostly by smaller companies. The third was the enterprise architecture with 34 % of companies missing employees equipped with this skill. The last one, enterprise architecture was also the fastest growing lack of skill with a 26 % increase compared to previous year. The shortage of digital-savvy labor is a common problem in many countries, and in U.S. alone there will be approximately one million computing jobs more than there are suitable employees in 2020. According to Swartz (2017), a survey of 501 U.S. hiring managers were conducted in 2017, which indicated that there are currently some 500 000 open computing jobs all over the country but only 43 000 computer science students graduated in 2016. Also, the education is not seen as a good solution for the shortage of employees since only 11 % of employers say that higher education is very effective when considering the readiness of graduates towards skills needed in companies. Furthermore, 62 % said that students are not prepared well enough for the jobs. In Finland, it is estimated that there is a lack of 8000 - 20 000 employees with sufficient technological skills, like data analytics and Internet of Things (Teknologiategollisuus 2018). The shortage of technologically competent employees reflects to higher salaries since bigger companies, like Baidu USA and Google, are offering a starting salary of 110 000-175 000 USD per annum for machine learning engineers (CBInsights 2018). The high salaries pose a significant barrier to smaller companies trying to compete in high-technology markets because they cannot afford to pay as high salaries as the large global companies.

In addition, only 25 % saw the lack of budget as a major issue, and on average 34 % of IT executives were investing or were planning to invest in digital labor in 2017. However, 62 % of respondents from bigger organizations were investing in digital labor, compared with 27 % of peers in smaller companies. The main reason for investing was the belief that digital labor is most effective at improving quality, ahead of value efficiency reason. It is more common to invest in current workforce than hiring new ones with sufficient digital skills. Circa 62 % of companies are trying to modernize their current employees' digital skills with new training programs, whereas only half of companies are investing in new digital talents. (Harvey Nash Group and KPMG 2017; Solis 2017)

Solis (2017) notes that there is a contradiction between the know-how and actions since 65% of companies in 2017 were prioritizing the evolvement of customer behaviors and preferences as the number one driver for digital transformation. Despite acknowledging this issue, only 35 % of these same companies had fully surveyed their customers' journeys in the previous year. Also, less than half of them invested in understanding the changing preferences of their employees and customers. Understanding the customer preferences are crucial especially in service-based sectors where customer demand change, service expectations vary, and technological advances bring new opportunities (D'Emidio et al. 2015).

2.2 Managing digitalization and digital transformation

Digitalization and digital transformation are not easy to manage, as was discussed in the previous chapters, so companies are clearly not aware of how to implement these new digital technologies into their businesses. In addition, companies are currently investing and are going to invest heavily on digital technologies in the near future: IDC (2017) estimated that 1,2 trillion USD was spent worldwide on digital transformation technologies in 2017, which was an increase of 17,8 % over 2016. The biggest portion of the total spending on digital transformation consisted of connectivity services, information technology services and application development & deployment, whereas, over half of the total investments were made in technologies supporting operating model innovations. The purpose of these investments is to make business operations more effective and responsive by utilizing all digitally-connected services, products, people, assets and other partners. Furthermore, it is expected that with this kind of annual growth, the spend will reach 2 trillion USD by the year 2020, and the fastest growth is expected to happen in healthcare, retail, insurance and banking industries. The three fastest growing technology categories related to digital transformation over the next five years are expected to be cloud infrastructure (29,4 % annual growth rate), business services (22 % annual growth rate and applications (21,8 % annual growth rate). This said, this chapter will focus on the approaches and methods to manage digitalization and digital transformation within companies.

If a company desires to implement and manage their digital strategies more efficiently, they first need to change their approaches and ways of thinking because improvement does not

come without changes and innovations. Because of the context of this thesis, it is important to differentiate the terms innovation and improvement from each other: they are usually determined by the scope and magnitude of the change, and thus, they depend on the situation. (Provost and Sproul 1996, 101)

Arora et al. (2017) mention many reasons behind the failures in digital transformation, but also the ways of tackling these problems. They say that many businesses are not willing to take risk when considering new technological strategies because companies that do not just make incremental changes are actually managing their business more efficiently than those who take cautious steps. In brief, companies should boldly and with common sense take bigger steps towards new technologies, and if they fail the company can learn from its mistakes and try again. However, this task is hard to accomplish because sometimes technological investments can be very expensive, but those more traditional technologies that are cheaper should be implemented without hesitation. Shein (2017) has similar thoughts that there will always be people resisting changes, and therefore, she suggests that executives should just be unapologetic and not listen to these resisting employees. By doing so, companies can gather a group of early adopters and best innovators within the company more easily, and by focusing on these people executives can create stronger influence and drive the change process more efficiently when they have the support of the most enthusiastic people. In brief, executives cannot be weak-hearted, and they need to get used to being comfortable with constantly being uncomfortable.

The digital transformation process should be started with the identification of where the value is created and destroyed in order to know where to focus the resources and what kind of workforce is needed to drive the change. Also, it is easy just to conduct an analysis comparing only one's own industry and competitors, but this is not the best solution. Instead, companies should always benchmark new ideas from completely new industries and companies because this way they could find new opportunities, which their competitors might not yet have and implement them into their own businesses after a careful internal analysis. Furthermore, many companies try to focus on various different experimentations at once, and thus, lose valuable resources from those scalable and valuable experiments. When considering large companies with revenues over 5 billion USD, scaled-up digital initiatives require a funding of 10-30 million USD, when as a major digital transformation

reaching various business units globally can require up to 100 million USD. To ensure to find these most important initiatives to invest in, the company must understand its customers' needs and create solutions that not only address them but have the potential to generate a strong impact. (Arora et al. 2017)

As previously mentioned, the workforce equipped with advanced technological skills can be very expensive due to the high salaries the workforce earns. In addition, a digital transformation at a large organization can require up to 150 full-time employees only in the first operating year. Luckily, there are ways of tackling this problem. A good way is to create an inviting start-up-like environment where employees can easily share ideas, create new innovations in their own ways and to attract new talents. One case company needed 11 people with certain skill sets to start a transformation project, and it hired them from a leading technology company by paying a 100 % premium so that they would join their team. Later it managed to hire 50 people more by only paying them 20 % premium because they were more willing to join the company because of their existing employees and working environment. After less than a year, the team successfully generated over one billion USD of revenue, which was a huge payoff compared to the expensive starting investments. In addition to creating a sufficient working environment, the company should broaden its operations towards a more collaborated approach by engaging with an ecosystem of different kinds of partners and vendors. This way the company can access more easily to new markets, and acquire talents, capabilities and technologies. In other words, it is important not to do everything alone, but instead, collaborate and enhance relationships with all of the company's stakeholders to manage digital transformation more efficiently. (Arora et al. 2017)

Companies do not always need to employ new people with new skills. Abood and Quilligan (2018) say that companies could also improve their current staff's digital capabilities by equipping them with modern technologies that help them to co-operate with other technologies. By doing so, it would be easier for the staff to get familiar with the new digital technologies. In addition, the executives should encourage the current staff to collaborate with the machines since many employees can resist the new changes and innovations. Airbus is a good example of a company that equipped its factory workers with smart glasses that helped them to determine the cabin's seating design. The glasses displayed the required

information to the workers about where to install the seats and allowed them to retrieve critical information about parts needed for the job. As a result of this new experiment, productivity in the cabin-seating installation process improved by 500 percent and the error rate went down to zero.

Holes (2016) suggests similar approach to capture external knowledge and new perspectives: companies could establish strategic alliances that would increase the chances of finding new technologies and business models, share risks, and combine the partners' complementary assets. She also notes that collaboration should also be done with customers, which could lead to new innovation impulses in the area of customer service and experience. A good example is BMW's project called Customer Innovation Lab that actively integrates customers in the development process of BMW's new technologies, and thus, producing market-ready ideas. Similarly, in the car manufacturing industry, Volkswagen Group's TOGETHER Strategy 2025 aims for a better collaboration between every stakeholder in order to decentralize the structure, shorten decision-making processes, cut costs, optimize business portfolio to meet customer demands, and transform the core business towards a more digitally and technologically advanced organization (Volkswagen 2018).

D'Emidio et al. (2015) point out that services are an essential part of companies' business nowadays and therefore they also take part in the creation process of efficient supply chains. Moreover, the same service improvement methods can also be applied to the digitalization and digital transformation processes. Services are currently representing approximately 65 percent of total global gross domestic product, and they are expected to grow up to 75 percent of global growth during the next decade. Competition is often fierce, and therefore, companies that are able to implement digital technologies in their businesses are more likely to capture a bigger portion of this growth because technological advances bring new possibilities all the time. To succeed in this new environment, the authors have found three key approaches companies should consider. To manage these approaches, they suggest companies to promote more collaborative methods of working to make sure that the focus is on the customers, not on the internal processes. The approaches are:

1. Companies should focus on matching service innovations with the resources and efforts that product-based companies put to their research and development. In other

words, companies should develop their services in the same style as they develop products because they also expire in a rapidly changing environment.

2. Make the customer experience more personalized and help customers do things themselves. Until recently, companies have tended to focus on customer segments or groups because their resources have not been sufficient enough to go any further on personalization. Now the modern digital technologies allow companies to personalize their customer base to a much higher degree, which means that they gain more detailed data about their individual customers and thus can modify their supply chain to work according to the needs of customers. Also, by gaining more data, the management of digitalization and digital transformation becomes easier since the company knows where and how to focus their efforts. The management process gets even more cost-efficient when the customers voluntarily give information about themselves. For example, Disney sold wristbands equipped with RFID that enabled Disney to track every movement of their customers who wore the wristbands.
3. Simplify service delivery. Especially large companies with heavy and complex IT systems often struggle to manage digital transformation, whereas, new smaller companies have lighter systems and can therefore keep things simple. One way the larger companies can make their processes more simplified is by taking the customers' perspective. This way the company understands better what the most valuable offerings for the customers are and thus, can cut all the non-value adding processes. If doing so, both the customers and the company benefit from it since the customers get better service and the company saves resources by only doing the necessary processes.

Abood and Quilligan (2018) have a few more suggestions regarding the management of digital transformation: transforming the core and focusing on both experiences and outcomes. The first one means that companies should ensure that all of their physical machines and software systems are synchronized to operate together, which would lead to cost efficiencies and driving up the investment capacity. In other words, when all relevant parts of the company can process the same data and work together, they become much more effective than having multiple different systems and technologies that do not collaborate

well. The second one means that companies should invest more on technologies and ways that personalize the customer experience by using for example smart touchpoints. Investing in these technologies would enhance the customer engagement and therefore grow the core business. Huawei leveraged this kind of approach when they developed an automated network traffic control system called Network Mind that enables self-adjusting control of voice and data services in vast networks. Network Mind uses for instance online deep reinforcement learning and live big data mining that allow the system to constantly adapt and renew itself to meet the changes occurring in network conditions. Due to this new approach, the system is up to 500 percent more efficient than current control methods in meeting key performance indicators, like policy generation.

Karna (2017) emphasizes the leadership's role in the change management of digitalization since he thinks that a proper leadership is one of the biggest imperatives for successful change management. First of all, new digital technologies may cause a feeling of insecurity among the staff because they are worried that they will, for instance, make them obscure or require to reskill themselves. A good leader must find ways to overcome these kinds of panics among employees by sufficient leadership commitment, stakeholder engagement and constant communication. Secondly, when concerning change researchers have found that brains react to resistance not only with a psychological reaction but also with a physiological reaction. This is especially the case with senior staff members who are not used to working with digital technologies. To overcome this perception, leaders should acknowledge that all employees are not the same, and they could even utilize analytical tools to gain an understanding of the staff's concerns and how to address them. When leaders understand what the various reasons for opposition among the staff are, they can more easily reskill the employees to tackle these problems. Thirdly, the change must be paced correctly since transforming too fast can increase the probability of errors. However, transforming too slowly is safer in the short term but will be disastrous in the long term because of the highly competitive global environment. Leaders can manage the pace and timing of the change by overseeing the project accordingly, which means staying focused and significant at each step of the change process. In addition, all the important stakeholders must ensure that the change process is moving quickly enough while at the same time minimize the likelihood of errors.

3 Digital technologies

In this section, the digital technologies will be presented according to the research questions. For every technology, the basic fundamentals will first be explained, and after that they are reflected to the supply chain context e.g. how could they be used in the management of supply chains. The benefits and threats of each technology will be assessed, and in addition, the objective is to find real life examples of companies using them and discuss how they are helping to manage supply chains more efficiently. Because many of these digital technologies are fairly new, not all of them are in full use yet, and that is why the expected future of these technologies are also assessed. This chapter will begin with themes about data analytics and Big Data since many modern digital technologies require data analytics at some level.

3.1 Data analytics and Big Data

There were around 3 zettabytes (1 + 21 zeros of bytes) of information stored all around the world in 2012, and by the year 2020 the amount is expected to be 50 times larger, from which half is unprotected. In 2016 it was estimated that the cumulative size of all the world's data centers equaled 16 000 acres. To put this into perspective, the 16 000 acres is equivalent in area to a two-lane highway reaching from Tokyo to San Francisco, which is roughly 8000 kilometers. Of all the data stored, 33 percent could be useful if companies would appropriately tag and analyze them, but despite this vast amount of potential data, only 0,5 percent is being analyzed. (SAS 2018) Because the amount of data stored in the digital universe is approximately doubling annually, traditional technological systems are not capable of managing it. Therefore, new technologies and methods are needed to collect, store and analyze the data. Big Data analytics can be very lucrative to utilize, for instance, a retailer using Big Data at its fullest potential has the opportunity to increase its operating margin by over 60 percent (Pusala et al 2016, 36; Manyika et al. 2011)

Data analytics is a combination of different methods that are meant to create new information and models from collected data. Data analytics together with both data processing and visualization has been a rapidly growing trend amongst many companies operating in

various industries in the past decade. The main reason behind this trend is that new technologies allow companies and their employees to conduct solutions that create competitive edge from their own data sources without a need of any significant coding skills or vast resources. Data analytics has gone a long way since before data was often stored in only a few places or inside an expert's head. Nowadays data is stored and available in various places, such as cloud technologies, information banks of operative systems. Traditionally the workload of a data analyst has divided unequally because a vast majority of the working time has gone to the process of prepping the data in a useful form, which leads to a situation where the analysts spare only a little time on data analyzing. (Solutive 2018)

Manyika et al. (2011) describe Big Data as the next huge step towards competition, productivity and innovation. Big Data also relates to datasets that are impossible to capture, store, manage or analyze by any traditional database software tool. Big Data plays a huge role in the fields of data analytics and supply chain management, and by combining these two fields we can create supply chain management (SCM) Big Data analytics. Rozados and Tjahjono (2014) describe is as follows: *SCM Big Data Analytics is the process of applying advanced analytics techniques in combination with SCM theory to datasets whose volume, velocity or variety require information technology tools from the Big Data technology stack; leveraging supply chain professionals with the ability to continually sense and respond to SCM relevant problems by providing accurate and timely business insights.*

It is expected that decision-making by using Big Data will have a similar type of effect on productivity and efficiency as information and communication technology had in the 1990's and early 2000's (Peres and Hilbert 2010). Big Data is refurbishing the conventional ways companies are managing their data in order to understand the source, in this case the world, from which it is collected. The traditional way of developing methods for analyses is done by collecting data for a certain purpose with a previously planned method. Big Data, in turn, equals to vast amounts of high dimensional and usually unstructured data that are constantly collected and stored with much lower costs than ever before. However, companies are able to analyze only little amount of the data they collect and store, which easily leads to an overload of information. For instance, financial credit card and health care providers currently discard about 80-90 percent of the data they are generating (Pyne and Rao 2016; Zikopoulos, Eaton, deRoos, Detusch and Lapis 2012).

The importance of Big Data does not revolve around how much data a company has, but rather how they utilize it. Data can be found everywhere, and it can be analyzed to enable several matters, such as cost and time reductions, new product development and optimized offering, and smart decision making. Furthermore, if companies combine Big Data together with modern and powerful analytics, they can achieve many valuable business-related objectives, like determining root causes of errors, mistakes and defects almost instantly, creating discount coupons for customers based on their buying habits, reconfiguring risk portfolio very quickly, and detecting fraudulent behavior before it makes an impact on the company. These are just a few examples of the possibilities of Big Data analytics. (SAS 2018)

According to Lustig, Dietrich, Johnson and Dziekan (2010) data analytics can be classified into three main sub-types (see figure 1 below): descriptive, predictive and prescriptive analytics. Descriptive analytics can be used to describe some historical business situations in such a way that trends, patterns and exceptions are well considered. This kind of analysis will help to determine the future approaches of the company by gaining a better insight of the past and answering the question “what happened?”. There are many techniques that can be used with this analytics method, such as standard reporting and dashboards, ad-hoc reporting, query drill down, alerts and visualization. These techniques help to visualize the situation more thoroughly.

Predictive analytics on the other hand analyses both historical and real-time data with an objective to create predictions about the future in the form of probabilities. It utilizes technologies that are able to learn from the data themselves, which includes the use of machine learning and many more computational algorithms of data mining. These algorithmic-based techniques used in predictive analytics often include at least the following:

- 1) Advanced forecasting and time series methods, which are often used for example in the prediction of sales or safety stocks.
- 2) Supervised learning that comprises of regression, linear and logistic analyses, and statistical algorithms.

- 3) Clustering, which is the most unsupervised learning method including hierarchical, k-means and density-based models.
- 4) Dimensionality reduction, which includes t-distributed stochastic neighbor embedding. (Siegel 2013)

According to Lustig et al. (2010) prescriptive analytics is being used to inform companies and to suggest them actions that are meant to take advantage or avoid a certain outcome. These suggestions are predictions that are based on the analysis of comprehensive data. This analytics method also includes the what/if analysis and game theory, which are used to address the variability of an expected outcome. It is often associated with optimization and simulation in the context of uncertainty, or in other words it should be used when companies are unaware of their future. Prescriptive analysis method is not that commonly used since Gartner (2012) mentions that only 3 percent of companies use this method in their decision-making.

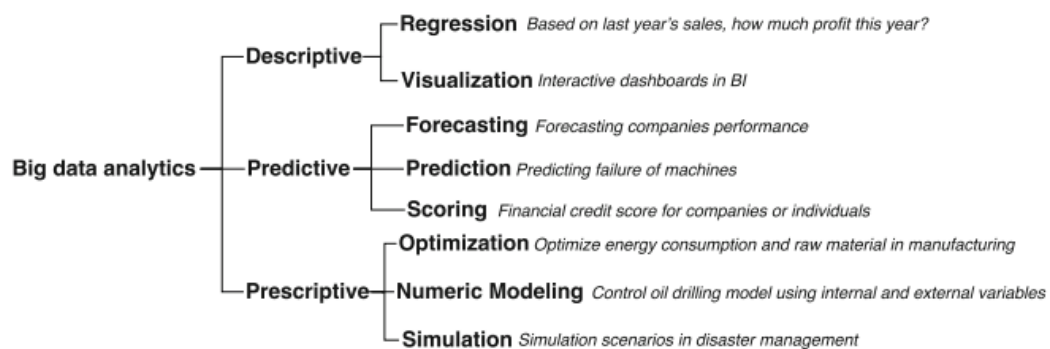


Figure 1 Forms of data analytics as depicted by Pusala, Salehi, Katukuri and Raghavan (2016)

Laney (2001) proposes a framework that explains the rapid increase of data and the characteristics of Big Data based on three Vs, which are Volume, Velocity and Variety. Big Data datasets become increasingly relevant factors when their volume exceeds the capacity of the “ordinary” database management. For instance, Intel determines that those companies who create around 300 terabytes of data every week belong in the Big Data volume generators group. Velocity in this context means the constantly accelerating speed in which data is created all around the world, but it can also be referred to as the transmission of data moving from batch processing to a real-time operation. IBM has stated that 2,5 quintillion bytes of data is created every day and this accelerating speed of data creation means that 90 percent of the total data ever created has been created during the past two years. Variety

means that Big Data can appear in various formats. Until the recent years, structured data has been the normal way of storing data but now companies are starting to use the unstructured format, like blogs, emails and messages.

Gudivada et al. (2015) add two more characteristics in addition to the three previous ones: variability and veracity. Variability means the variation in the data flow during a certain time period, such as one day or one week. Retail business is a good example since they pose a much higher demand in Christmas time than other times of the year, thus leading to different kinds of data received from many sources relating to this retailer. Retailers built in-house infrastructure to handle these variations in demand, but they turned out to be too costly since they were idle for the rest of the year. Luckily the advanced distributed computing platform, also called as the cloud, emerged. It enables on-demand resource handling via third party companies. As previously mentioned, Big Data provides benefits in decision-making and analytics, but despite this, only a small fraction of the total data created is harnessed properly. However, even a smaller fraction of the total data is actually considered as valuable data. Veracity refers to the valuable data where the value is extracted from, and the optimal solution for companies is to obtain this data and find hidden information from it.

Rozados and Tjahjono (2014) say that Big Data analytics is driving supply chains forward in the format of four different levers, which are marketing, procurement, warehouse and transportation. Marketing means that companies are getting many kinds of valuable information about their customers' preferences and this information could be sent upstream in the supply chain network, which would help all the companies in the network to plan their offerings to meet the preferences. Moreover, to manage the marketing lever efficiently, these customer inputs must be properly aligned with the SCM systems and supply chain managers must focus more on the customers rather than the suppliers. Global supply chains tend to be very complex nowadays, thus leading to complex purchasing strategies. However, Big Data analytics helps in this procurement activity by making the spend data more visible and achieving granular levels on aggregated procurement patterns. This is especially important because external expenditure can add up to 50 percent of a company's cost structure, and these external expenditures are usually inconsistently categorized and left without an integration with the internal costs. In means of the warehouse lever, warehouse management has changed drastically during the digital era with the help of many technologies, like RFID

and Internet of Things, and all these new technologies usually need Big Data analytics to collaborate with each other and to work sufficiently. Big Data analytics help transportation in many ways, such as creating optimized delivery routes, estimating lead times by taking into consideration the weather and traffic conditions, and enabling intelligent transportation systems. All these levers, especially the two last ones, will be discussed in more detail during the next chapters because the technologies mentioned later will relate to them.

Despite data analytics' and Big Data's great opportunities and benefits, even they have downsides. Pusala et al. (2016, 32-35) discuss the issues Big Data analytics faces nowadays. They found five problems that are: data locality, fault-tolerance, replication, security and heterogeneity. One of the most crucial musts in efficient Big Data management is having a low latency when accessing the data. However, because Big Data consists of vast volume of data, it is hard to transfer it from place A to place B. Therefore, the computational technologies should be located near the locations where the data is coming from in order to minimize the data migration between data centers. Fault-tolerance correlates to the fact that Big Data analytics is run by machines, which are naturally critical to failures, and this means that they can break down at any time, thus, preventing the execution of analyses. This is the reason why companies should pay attention that the whole data analytics process does not stop if one or two computers crash. Replication means that Big Data analytics have two approaches to handle the data: do not replicate the data or do it automatically by using a distributed file system. Replication is important due to the fact that without it, a failure in a server can cause a re-execution of the affected tasks.

Security is often a key issue in business and the same applies to Big Data analytics because companies are concerned about the confidentiality of it. Confidentiality is a problem because of the amount of confidential user data migrated in the systems, such as medical information, is increasing in the data base and cloud. There is a solution to this problem however: to secure this confidential data companies can employ cryptographic techniques in them. Despite the benefits, these techniques have a downside, which is that they limit the cloud-based Big Data analytics by many ways, such as limiting the transparency to end-user and restricting searching and processing functionalities. Other methods to secure the data confidentiality are to use multiple cloud storage units at the same time and hybrid clouds. In the first one, data is fragmented based on a user-side hashing function and then the data will

be encrypted and stored in various clouds. Hybrid clouds have a proven track record in increasing the security, especially in cases where a portion of the data is sensitive, thus needing trusted resources to execute. The last problem mentioned was the heterogeneity of the data, which means that the data is hard to compile because the sources vary by data structure, format and semantics. Therefore, the data can be well-structured, like databases, or unstructured, like heterogeneous documents. (Pusala et al. 2016, 32-35)

3.2 Internet of Things

Greenough and Camhi (2016) have estimated that there will be 34 billion devices connected to the internet by the year 2020 when as it was only 10 billion devices in 2015. As a comparison, Internet of Things (IoT) devices will account for 24 billion, whereas, traditional computing devices, for instance, smartphones and tablets, only comprise 10 billion. Bughin et al. (2018) on the other hand estimate that almost 6 trillion USD will be spent on IoT solutions during the next five years worldwide. IoT, combined with advanced and thorough analytics, enable companies for instance to predict the maintenance needs of capital goods, which extends their life duration and creates a new pathway for industrial productivity. Ellis et al. (2015) point out that IoT will also support supply chains and their many issues in many other ways, such as providing agility, transparency and adaptability.

The history of IoT dates back to early 1990's when its predecessor, the concept of connected devices, was first used in MIT. The term *Internet of Things* was first used by Kevin Ashton who was the director of the Centre in 1999. (Greengard 2015) There are no exact definition to IoT, thus, a few different examples are given. INFSO (2008) describes it as *Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts*. Gubbi et al. (2013) on the other hand describe it a bit differently: *interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless large-scale sensing, data analytics and information representation using cutting edge ubiquitous sensing and cloud computing*. In brief, IoT refers to devices and sensors that are connected to the World Wide Web.

According to Lee and Lee (2015) IoT consists of five different technologies that together make it work efficiently: RFID, WSN, Middleware, cloud computing and IoT applications.

RFID refers to Radio-frequency identification, which allows companies to identify, track and transmit information. The operation is based on the storing of data and its reading from a small tag through radio waves with a wireless RFID reader. The benefits of this technology are that they are easy, quick and secure to read from a distance, they can sustain even a heavy treatment, and they stay functional for tens of years. This technology has been available for a couple of decades now and the popularity is constantly increasing. (RIFFID 2018) Not every RFID tag is the same kind since López et al. (2011) say that they can be categorized into five separate classes. The first class contains passive tags equipped with only a read or write memory. Class 2 tags are the same, but they are equipped with more secure functionalities. The third class includes battery-powered semi-passive tags with a possibility to add sensors on them. The fourth class also contains battery-powered tags, but the difference to the previous class is that they are able to communicate with similar tags. The last and fifth class includes tags with the capability of activating other tags and they are directly connected to back-end networks. In conclusion, the higher the class is, the more sophisticated the tag evolves, and the upper classes contain all the same functionalities as the lower-class tags.

WSN stands for wireless sensor networks. It is a network with a combination of sensors that monitor and track the status of items, such as temperature, pressure and location. Traditionally WSN have been used in temperature-controlled chain logistics, but the variety of use is expanding because this technology enables many things, like resource efficiency and preventive maintenance. Middleware on the other hand is a software layer that eases the work of software developers to communicate with heterogeneous devices. It has a feature that allows to hide the details of separate technologies, and this frees IoT developers to use their time on relevant IoT applications, not on irrelevant software services. Already in 1980's this technology gained popularity due to its capability of simplifying the integration of legacy systems into new ones. (Lee and Lee 2015; Hsueh and Chang 2010)

Cloud computing is an internet-based computing platform which offers sharing place for different computing resources and access to them immediately. This technology is crucial for IoT to operate properly because the amount of data generated through the IoT devices is

huge and cloud solutions provide a suitable place to store this data and analyze it. Cloud partially plays the same role as middleware since their main objective of them is to connect the IoT devices with IoT applications. There are many cloud platforms available on the market and they can roughly be categorized into four types according to their characteristics: security, event monitoring, connectivity and advanced analytics. The last technology is the IoT applications, which enable both device-to-device and human-to-device interaction. The purpose of them is to present the data in an intuitive and easy to understand way, detect difficulties, and propose solutions. To achieve these objectives, even without human involvement, the IoT applications must be equipped with intelligence. (Ben-Daya, Hassini and Bahroun 2017; Lee and Lee 2015)

IoT offers plenty of potential for companies. Chui et al. (2010) have classified the opportunities and possible applications of IoT into two broad categories, which both include three different smaller sub-categories. The two broader categories are information and analysis, and automation and control. The first includes tracking behavior, enhanced situational awareness, and sensor-driven decision analytics. The second includes process optimization, optimized resource consumption, and complex autonomous systems. Some of these following topics are based on future expectations because many of them are yet to be achieved by many companies. Furthermore, some of these opportunities are still in the experimental stage or unreachable due to the current lack of sufficient technologies.

Information and analysis means that IoT provides so much information for companies to analyze their operations, thus, enhancing the decision-making. Tracking behavior was the first application in this category. Part of the IoT is that products can be embedded with sensors, which allows companies to track the movements of these goods all around the world. This tracking offers knowledge of the products and their delivery routes, which in turn, can help the company to determine for example risk issues or adjust the pricing policy. RFID technology plays a significant role in this due to them offering tags that can be read by carriers' sensors. Furthermore, when companies know the exact location of the goods, their inventory management becomes easier and more efficient by reducing congestion costs and making continuous adjustments on delivery times and routes. The second application is the enhanced situational awareness, which is slightly similar than the first one. Sensors and devices that collaborate together help companies to understand their physical environment

better, for instance, security issues can be handled effectively when possible intruders or risk factors can be detected by cameras, audio and vibration sensors. The third application is the sensor-driven decision analytics. By using multiple sensors companies can detect new sources of raw material quicker and from a larger area with lower costs than previously. Sensors can also help to understand customer movements and decision-making, which in turn, helps to optimize the amount of goods needed in a certain place in a certain time. (Chui et al. 2010)

Automation and control is the second major category, which refers to a situation where companies utilize the data collected from IoT devices to convert it into a useful information that helps actuators to amend processes according to the needs. This said, there is no need for humans to intervene a process when a computer automatically does the same work. Process optimization is the first application in this category, and it means that IoT is enables vast improvements in processes, such as in production where the sensors make the monitoring much more granular. The sensors send data to computers that adjust the processes by, for instance, changing the quantity of some ingredient or repositioning an item to some better part of the assembly line. This optimization of production reduces waste, energy costs and the need for human intervention. The second application in this category is the optimized resource consumption which is also similar to the first one. IoT and its sensors can help computers to learn patterns in production, and by doing so, the computers can learn to optimize the usage of certain systems or raw materials to meet the off-peak hours, thus, leaving no unused resources and changing processes to be done in lower-priced periods. The third and last application is the complex autonomous systems. The most demanding task of IoT is its capability of sensing real-time conditions and to response to them by automated systems. The goal of this is to mimic human-like decision-making process, but with much higher performance levels, which would lead to a prevention of accidents and mistakes in every vulnerable part of the company, such as in logistics. (Chui et al. 2010)

Despite the opportunities, IoT faces many challenges. Arrow (2017, 22-24) conducted an IoT-concerned survey where they interviewed 60 large companies operating in Finland two times between years 2015 and 2017. They found many challenges among the companies and in specific industries. For example, the main challenge among all companies was that the markets were not ready to utilize IoT. In energy industry the biggest challenges were the

technological and juridical issues, even though, the business culture strongly supports the use of IoT. Furthermore, in construction industry the attitude towards this technology was very favorable. The lack of skilled workforce was also one of the top issues among all companies.

As mentioned in the beginning of this chapter, the amount of IoT devices are expected to grow exponentially in the near future. However, the future is not all about the quantity of IoT devices but also many other things. Press (2017) summarizes a few main points from Forrester Research's report regarding other types of futures of IoT. Firstly, devices will better understand voice commands and Fortune 500 companies are expected to invest twice as much money than before in voice-based services in 2018. Secondly, the spread of IoT technologies has not been equal all around the world for many reasons, for instance, 45 percent of data analytics decision makers in United States are already commercializing their data, while at the same time, only less than 40 percent of Western Europe countries are doing so. Therefore, it is expected that the public sector, especially in Europe, is starting to encourage the use of IoT and other advanced technologies much stronger in order to develop the data economy further. Thirdly, the development of IoT-relating software is starting to focus more on platforms that integrate companies' diverse sets of IoT assets into one cohesive business process that can be operated from both distance and automatically. Also, companies are starting to push the data analysis and processing to the edge of their networks to decrease data ingestions costs and reduce network latency. This kind of solution is more expensive since IoT platforms have to concentrate also on other parts of the network than just the core business. Because the expenses and demands rise, the amount of IoT platform providers are expected to decrease. Fourthly, the security issues become more evitable since companies focus more on the other functions of their IoT devices, such as delivering the product quickly to the markets or saving costs. The lack of security makes the devices more vulnerable to cyberattacks, and thus, these attacks are predicted to increase when hackers try to seek sensitive data. Lastly, there has been lately some promising projects regarding the use of blockchain in IoT technology. Therefore, it can be expected that these two technologies are beginning to adopt together.

3.3 Artificial intelligence

Artificial intelligence (AI) was originally meant to develop and create thinking machines that were able to mimic, learn and replace the human's intelligence. Starting from early 1980's, AI has been promising to improve the processes of human decision-making and enhance the productivity in multiple business industries due to its capability of recognizing business-related process patterns, learning business activities, and retrieve and analyze data with human-like intelligence. Despite the opportunities, artificial intelligence has not been widely used in supply chain management. (Min 2010, 13)

According to Ertel (2011, 1-2) AI is hard to define and there exists various forms of it that differ from each other. The first known definition of AI was mentioned by one of the technology's pioneers, John McCarthy in 1956 and it was roughly like this: *The goal of artificial intelligence is to develop machines that behave as though they were intelligent.* This definition, however, is not considered as sufficient enough in today's markets, and thus, Encyclopedia Britannica (1991) defines the term artificial intelligence as follows: *AI is the ability of digital computers or computer-controlled robots to solve problems that are normally associated with the higher intellectual processing capabilities of humans.* This definition also has its negatives since it practically says that every modern computer is an AI system. The previous definition admits that a computer is highly intelligent in the same way as humans are because, for instance, they can multiply numbers and retrieve, display on demand and memorize long texts. Therefore, a more suitable definition from Rich (1983) would be: *Artificial intelligence is the study of how to make computers do things at which, at the moment, people are better.* Even though this definition is many decades old, it is expected to last for many decades more from now on.

As previously mentioned, AI has been known for decades, yet the technology has been rapidly evolving and gaining popularity due to better access to more data through other modern technologies, such as IoT and improved access to processing power, like via cloud technologies. Moreover, the vast amount of data stored in networks is making the algorithms smarter, hence, creating opportunities for companies using AI to create substantial benefits, e.g. customer loyalty, enhanced quality, lower costs, and improved agility. AI also enables tailored offers and recommendations that can be scaled fairly easily, which leads to

possibilities in creating vast efficiencies across companies' value chains. Companies are entering a new era where it is a significant advantage for every organization who is able to handle data in order to create both customer and operational value. (Teigland et al. 2018)

Chui et al. (2018) have classified the development and history of AI into three categories, which all have developed individually in different phases: algorithmic advances, explosion of data and exponential increase in computing power and storage. The history of algorithmic advances can be dated all the way back to 1805 when French mathematician Adrien-Marie Legendre laid the groundwork for machine learning. The next milestone occurred in 1958 when Rosenblatt developed the first self-learning algorithm. Soon, in 1965, the deep learning was born by Ivakhnenko developed the first general working learning algorithms for supervised multilayer artificial neural networks. The explosion of data started in 1991 when the World Wide Web was launched to the public. The amount of data created in the Web started to increase exponentially when the first major social media platforms, such as Facebook and YouTube, were introduced in 2004 and 2005. Also, 2005 was a breakthrough year in this context due to it being the year when the total amount of Internet users passed one billion users. In 2007, iPhone was launched, which started the era of smartphones creating plenty more data all over the world.

The exponential increase in computing power and storage started in 1965 when Intel's cofounder, Gordon Moore, recognized the exponential growth in chip power. The Moore's law means that the number of transistors per square inch on integrated circuits doubles every year, even though, the doubling period is actually proven to be 18 months. The first major breakthrough in computing power and engineering occurred in 1997 when IBM's Deep Blue won Garry Kasparov in a chess game. One of the first well-known cloud storages, Amazon Web Services, was introduced by Amazon in 2002, and it offered cloud-based storage and computing power to its users with relatively low cost. Before this, only large companies could afford such services. In comparison, Google Cloud Storage and Microsoft's Azure were launched in 2010. These three categories were well combined in 2009 in the context of AI when a team in Stanford University proved that training deep-belief networks on graphics processing unit is over 70 times efficient than doing so with central processing unit. This finding reduced the deep-learning training time from weeks to only a single day. The possibilities of AI came to the public's awareness in 2011 when IBM's Watson beat the

champions in the question answering game, Jeopardy. After this there has been many developments in the field of AI and technologies close to it. (Chui et al. 2018)

With the aid of the three previously mentioned categories artificial intelligence is finally, after decades of development and billions in investments, starting to show some signs of bringing real value for companies and their multiple different business operations, such as automating warehouse management, forecasting future trends and assisting self-driving cars (Bughin et al. 2017). Even though AI has plenty of potential in benefitting companies and supply chain management, it is not the “almighty business solution” to many problems but rather an enabler for business process improvement, which in turn, requires changes in business processes to work properly (McKinsey 2018, 3). Some applications have been made in applying AI to supply chain management, but not all of them will be mentioned because there are so many different aspects to consider. Nevertheless, AI can help to enhance supply chain management at least in six different ways that have been proved to work: inventory control and planning, transportation network design, purchasing and supply management, demand planning and forecasting, order-picking problems, e-synchronized supply chain management, and customer relationship management (Min 2010, 20).

Inventory equals unused resources which are required to sustain a good customer service but with high costs, for instance, annual costs for holding a single item in the warehouse can be up to 35 percent of the items value (Timme and Williams-Timme 2003). Therefore, Min (2010, 20) says that it is necessary for companies to be able to control and sustain an efficient inventory at minimum costs in order to stay competitive. Efficient inventory management can be achieved by accurate and real-time information about the demand, size and type of inventory, and length of the order cycle. This kind of information is not easy to manage with traditional methods, such as with economic order quantity model or human’s estimates. AI, with its vast capabilities, can offer a new promising solution for these problems because of its powerful knowledge representation language that can capture the detailed patterns of goods flowing across the supply chain, which enables humans to estimate the desired amount of goods in the warehouse without causing a bullwhip effect in the supply chain. In brief, AI can help companies to estimate the optimal level of future demand, and thus, optimal level of orders with optimal timing.

According to Min (2010, 21) transportation network design has been one of the pioneer supply chain areas in which artificial intelligence has been applied due to its intrinsically combinatorial problems that are hard to solve especially in a global context. Problems occur in transportation network design, for instance, in the fields of vehicle routing and scheduling, freight consolidation, minimum spanning tree, intermodal connection, parking space utilization and many more. Chambers (2001) suggests using genetic algorithm, a popular form of artificial intelligence, to handle these problems. Furthermore, Glover and Kochenberger (2003) say that even more productive would be to combine different forms of AI since it takes only a few modifications to adapt them to a certain problem.

According to Baily et al. (2005), common decision that companies face is the make-or-buy decision, which refers to a situation when the company has to decide whether to produce commodities internally or purchase them from someone else. Factors that should be considered when making this decision are, for instance, the volume of produced goods, needed capital investments for production, and the business environment in which the company is operating. To analyze these factors companies need systematic decision-making tools to help them do the right decisions. The right kind of systems can substitute or even replace the human's role as a decision-maker due to their capability of aiding the purchasing manager in numerous strategic purchasing decisions, whereas, the traditional methods can often handle only one aspect of purchasing. Nissen and Sengupta (2006) have proposed intelligent software agents that can automate the searching process of new suppliers from online catalogues, evaluate them thoroughly, and complete the purchase orders.

Any information about the future is valuable for companies because it enables them to plan and prepare all their operations with much more efficiency. The information should be as accurate as possible since inaccurate information is often useless to reduce the future uncertainty and variability. There have been multiple different forecasting methods that, for instance, pay attention on short or long-term predictions only, but the main common problem the current and previous forecasting methods have is that they assume the future trends are based on historical data. Artificial intelligence, however, poses viable alternatives for these older methods to predict and plan the future, and new methods have been proposed, such as a dynamic pattern matching procedure that can combine human expertise and data-mining

techniques to predict a product's demand without relying on historical data. (Yu et al. 2002; Min 2010, 22)

Order-picking refers to the process of picking items from the warehouse to fulfil the placed orders. Commonly, this process has been a labor-intensive operation and it usually accounts the largest share of total costs of warehousing operations, thus, affecting the productivity enormously. Because of the high costs, managers and executives are constantly trying to find new ways of improving this process to cut costs and make it more efficient. Popular methods to handle this order-picking process are computerization and automatization. In the past, the order-picking problem has been tackled by a variety of simulation and mathematical models, but AI techniques, e.g. intelligent agent-based systems and AI's inherent learning capability, are capable of handling the growing complexity caused by the adoption of value-added services and e-fulfillments much better. A good example of modern warehouse management is the Konecranes' Agilon system, which automatically retrieves the items than humans, learns to keep the stock in balance by learning the number of items by weighing them, predict demand spikes, and automatically send the stock information to the procurement department. These so called smart warehouses can cut costs and help to keep the inventory at optimal level. (Frazelle 2002; Min 2010, 23; Tilus and Vainiomäki 2018).

A company can manage its customer relationships (CRM) with the help of supply chain management by making the customers trust that the company will deliver its commodities on time and with good quality. This cannot be achieved without continuously communicating and creating lasting relationships with the customers since a well-handled CRM helps to plan the future demand. Artificial intelligence can ease the process of customer acquisition and the assessment of return of investment in CRM by finding automatically new prospects and organizing them properly. (Min 2010, 23)

E-synchronized supply chain management can help companies manage their supply chains in many ways. If companies desire to facilitate the coordination and integration of supply chain processes, they should share information regarding at least the forecasts of future demand, and production and distribution plans via electronic media, like Internet. Furthermore, if companies share enough information via electronic media, it creates a fruitful place for AI to apply its machine learning techniques, like web and text mining to

provide support for the business. Machine learning will be discussed in more detail in the next chapter. Especially web mining can be helpful because is used to extract new patterns and data from the Internet regarding the customers, suppliers, demand, sourcing and many more. Finding information from the Internet will also help companies to identify future customer bases, enhance pricing strategies and assess their business partners. (Min 2010, 23)

Artificial intelligence faces many challenges. Marr (2017) promotes the lack of computing power since AI and other technologies related to it require huge amounts of calculations to be made rapidly, which in turn, requires plenty of processing power. AI has been around for decades and many types of AI has been created in theory, but they have been impossible to put into practice due to the insufficient computing power. The solution is seen to rely on quantum computing that harnesses subatomic phenomena to carry out operations on data much quicker than current traditional computers. However, it has been estimated that this improvement will take at least five more years because the programming models are different. The second challenge he mentions is the narrow range in which AI implementations are being used currently. This means that current AI techniques are capable of handling only a certain specialized task, such as evaluating different outcomes of some business process. AI cannot currently be taught, or it cannot learn to consider out-of-the-box tasks or various inputs that humans can easily understand and solve. The third challenge is the lack of understanding, which means that AI has often being considered as science fiction or something that is being developed only in university IT research laboratories. This has led to smaller markets because companies are now willing to invest in AI technologies or in the development of skills related to it when they do not understand the concept or opportunities. Despite this, during the past few years the general mindset has switched to more compliant towards artificial intelligence and companies are starting to invest in it. Yet, there are still not enough people with the right skills in order to implement and harness the full potential of AI within companies.

The opportunities and future of AI are bright since the global gross domestic product (GDP) is expected to grow from 2016 to 2030 approximately 14 percent from which half is resulted because of the productivity improvements that AI offers. 14 percent is equivalent to 15,7 trillion USD. The distribution of growth coming from AI is not equal all around the world: China is expected to increase its GDP 26 percent in this same time period, whereas, North

America grows 14,5 percent. These two combined will account around 70 % of the global GDP growth. The biggest industries benefitting from AI are expected to be retail, financial services and healthcare. (PwC 2017)

3.3.1 Machine learning

Machine learning is an approach to create artificial intelligence since its output can be used to make recommendations, decisions and feedback mechanisms. Most often the current artificial intelligence techniques are based on machine learning, and that is one reason why these two techniques are regularly used as synonyms in the business context. On the contrary to the pre-programmed artificial intelligence, machine learning uses data to learn from it and classify it into categories by using algorithms that help it accomplish these tasks step by step. Thus, it constantly becomes better at describing the data it analyzes and through that at predicting future outcomes. When it has learned to describe and categorize the data, humans can provide it with inputs to let it determine the outputs based on them. In other words, machine learning helps to answer the phrase “if this, then that”. Machine learning became popular two decades ago when digitization advanced and cheaper computing power allowed data scientists to train computers to build finished models instead of building them with their own hands. The explosion of complex and unmanageable data (Big Data) requires using machine learning technology and it also increases the possibilities of benefitting from machine learning techniques. The more there is data available the more efficient the machine learning becomes. (McKinsey 2018, 12; Pyle and San José 2015; Merilehto 2018, 27-28)

Table 1 Models of machine learning as depicted by Merilehto (2018, 34)

Model	Purpose	Examples of usage
Classification	Classify a target to predefined two or more categories	Targeted marketing & Identifying a picture
Clustering	Analyze uncategorized data and detect different groups from it	Clustering a customer base with different variables & Analyzing the contents of a document or website

Regression	Predict a numeric value	Predicting the development of profitability & Predicting the time period for maintenance
Recommendation	Evaluate the products that customers like	E-commerce's purchasing recommendations
Anomaly Detection	Find abnormal data from a material	Detecting fraudulent use of credit cards & Finding defects from machinery

As seen in table 1, there are many different models and purposes for machine learning. It also shows how functional machine learning can be when considering different aspects of business and companies.

Merilehto (2017, 41-43) mentions three steps on how to utilize machine learning. Firstly, companies need to go through and list their business processes, such as the decisions that are constantly made in the same environment e.g. bank loans. The more there is data the better the results are. Secondly, it is important to concentrate in the clearest and most obvious challenge because artificial intelligence and machine learning work properly when their tasks are narrow enough. Again, it is important that there is enough data, and that the wanted result is quantitative. Thirdly, machines should support the decision-making. Human can depict the characteristics of successful factors from which cannot be found any data, when as, machine handles routine tasks and ensures that the existing data is used for decision-making purposes. In other words, machines provide supportive information for humans.

There is controversy between the expected benefits and actual benefits of machine learning. Google and MIT (2017) have conducted a survey where they gathered data about the use of machine learning among 375 companies ranging from small to large companies operating in several industries. According to this survey, a majority of respondents, 60 percent, were using or had implemented machine learning in their business operations and 30 percent of them recognized themselves as being in the mature stage of applying machine learning. The investments in this technology are fairly large since 26 percent of companies are using over

15 percent of the total IT budget in it. The companies not yet using machine learning were also expecting many benefits from it, such as better understanding of customers (50 percent), competitive advantage (48 percent), improved efficiency of internal processes (44 percent) and more extensive data analysis (45 percent). The most common benefit the respondents already using machine learning were seeking was better data analysis and insights with 50 percent saying so. The other major benefits were seen to be competitive advantage (46 percent), faster data analysis (45 percent) and enhanced R&D capabilities (44 percent). Despite the beneficial expectations, companies did not achieve these hoped benefits: 45 percent gained more extensive data analysis and insights, but only 35 percent gained faster data analysis and enhanced R&D capabilities, whereas, only 30 percent improved their internal efficiency and 27 percent understood their customer better. In brief, competitive advantage or other benefits did not meet the expectations relating to machine learning.

3.4 Cloud Computing

If companies desire to utilize automated technologies in their supply chains, it is crucial to understand that they consume a huge amount of processing power, and even a few years old systems may not be powerful enough to handle the continuously increasing stream of data moving between various systems. Nevertheless, cloud-based systems are a solution for this problem, and therefore many manufacturers and supply chain partners are exponentially starting to adopt this technology. It is estimated that more than 80 % of supply chains will have at least some portions resided within cloud technologies by the year 2020. Many industries can benefit greatly from cloud technologies, such as retailers who can combine their point-of-sale systems together with facilities and inventory management systems, which in turn, allows quicker replenishment and smaller supply chain costs. (Robinson 2018)

Microsoft Azure (2018) describes cloud computing as the delivery of computing services over the internet, which is called as “the cloud”. Companies that offer these services are called cloud providers and they usually charge the customer based on its usage. Cloud computing provides many benefits in terms of cost, speed, global scalability, productivity, performance and reliability. It saves costs because it eliminates the capital expenses of buying and spending on hardware, software, on-site datacenters and electricity for running all these physical elements. Cloud computing services offer speed due to their capability of

provisioning large amounts of computing resources within only a few mouse clicks, and it can be done on demand and independently. This gives companies more flexibility and eliminates the need of capacity planning. Cloud computing can be scaled elastically, which allows companies to deliver the right amount of IT resources, such as computing power or storage, to the right location worldwide at any time. The technology increases productivity by removing many tasks related to IT management, like setting up hardware or patching software, thus, allowing companies to focus their resources on more productive tasks. Enhanced performance is achieved because cloud computing services and their network of datacenters are constantly upgraded to make the computing hardware faster and more efficient, which in turn, reduces network latency and offers greater economies of scale. Cloud computing makes the business processes more reliable by creating backups of the data and mirroring it at several redundant sites on the cloud provider's network. This way data backup, business continuity and disaster recovery become cheaper and easier.

According to AWS (2018b) and IBM (2018) there are different models of cloud computing available in the market that companies can use, such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). These models can be deployed in the form of three models: public cloud, private cloud and hybrid cloud. The following information for the next chapters is based on the last two previously mentioned sources.

IaaS contains the basic building blocks for cloud that usually provides an access to networking features, computers and data storage base. It also provides high-level flexibility and management control over a company's IT resources, and it is very similar to the IT resources companies are currently using. The benefits are that companies do not need to invest in their own hardware and the infrastructure can be scaled on demand to support dynamic workflow. PaaS is a cloud-based environment that eliminates the need for companies to manage the underlying infrastructure and enables them to concentrate on the implementation and management of their applications. Therefore, they become more efficient due to not having to worry about resource procurement, patching, hosting, provisioning or any other non-value-adding task related to running an application. SaaS, also referred as end-user application, is a completed product that is operated by the service provider. When the service provider manages the service, the customer does not have to be

concerned about maintaining or managing the service, but instead, focus on taking advantage of it. For instance, web-based email is most often provided and maintained by the service provider, which allows the customer to only send and read the emails without managing any other features. SaaS also benefits companies in many other ways, like by enabling quick and easy use of new innovative business apps that are accessible from any connected computer or smartphone.

Public clouds are owned and managed by companies that are offering quick access to cost-effective computing resources with the help of public network. All parts of this service run inside the cloud, which leads to a situation where the customers do not need to acquire their own hardware, software or any other supporting infrastructure that are operated by the service provider. Furthermore, all parts are either been created in the cloud or have been transferred from a current infrastructure. Private cloud is the opposite to public cloud. It is an infrastructure build for one company and it can be operated by either the company itself or by the service provider. The hardware is usually located inside the company's premises, thus, offering good security and tailored operations according to the company's needs. The third deployment model is the hybrid model that combines the two previously mentioned together. Hybrid offers a way to connect the cloud-based resources to the existing resources that are located outside the cloud.

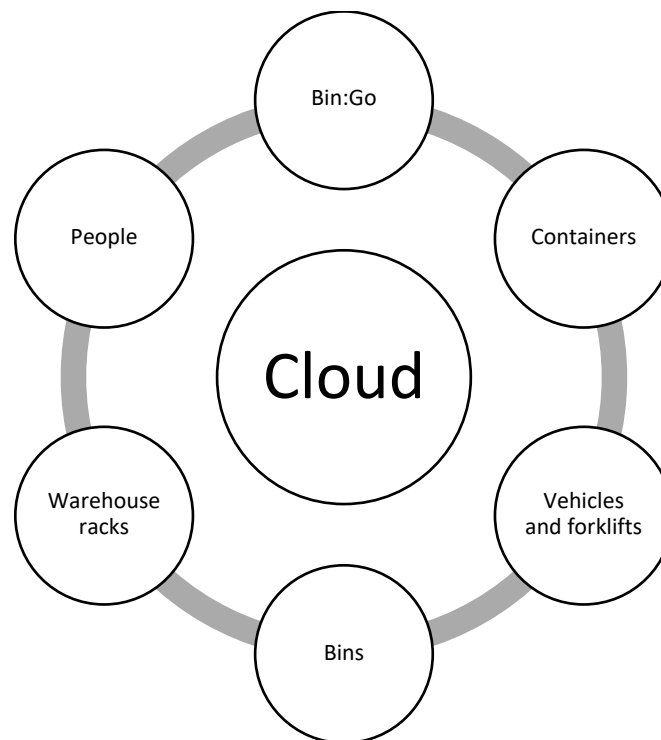


Figure 2 Example of how cloud connects several parts of supply chains (Virolainen 2018)

Virolainen (2018) gives an example (depicted in figure 1 above) of how cloud technology is able to connect various parts of supply chains, thus, turning processes autonomous. Bins refer to the information on what items to pick in the warehouse, warehouse racks mean that computers can create replenishment orders, people are able to plan and monitor processes more easier, Bin:Go refers to flexible warehouse equipment, containers can route themselves, and vehicles and forklifts are organized in swarms. Without cloud technologies this kind of connectivity and autonomous collaboration would not be possible.

There are a few main challenges facing cloud computing. Firstly, cloud computing can be affordable in its basic form, but the price quickly rises if one wants to tune the cloud according to the company's needs. Also, the transferring of data from private datasets to public clouds can prove to be much more expensive than expected for shorter and smaller projects. Secondly, cloud technologies can be created with relatively low costs, thus, enabling smaller companies to offer their cloud services. These smaller companies are not necessarily as reliable as the bigger ones because they do not have long-term experience or broad customer base. Therefore, companies purchasing cloud services from smaller firms are not guaranteed to have a long-term cooperation with the service provider or other

difficulties may occur. Thirdly, cloud technology is accessed via internet and because of that can sometimes face downtime during in which the company cannot use the service at all. Companies need to be able to access their data and services to operate their business, but when the internet is not working they cannot operate properly. (Casey 2015; Parker 2017)

Fourthly, security and privacy issues pose a major challenge. Because of the risk of cyberattacks or leaks causing reputational harm, CIOs are sometimes reluctant to provide any sensitive data to the cloud. Sensitive internal data should not be shared with third parties, but sometimes the business requires doing so, which causes a risk of leaking unwanted information. In addition, the more there are users in the cloud the more likely it becomes that, for instance, someone's password gets breached and the hacker gets an access to all the company's information in the cloud. Fifthly, companies must be careful when selecting the cloud service provider due to the fact that the technology is still fairly new and in its development stage. It can be challenging to find a cloud service that truly meets the needs of the company while also improving the efficiency. Transitioning to the cloud can be a long and complex process, and therefore, executives must understand the cloud service thoroughly before implementing it. In the worst-case scenario, the company invests heavily in the cloud technology and soon finds the service to be useless. The situation worsens when they try to switch the service and notice that there are no alternatives, or the switching is very difficult to accomplish. Hence, companies may be forced to stay operating with the bad service provider with high costs. (Casey 2015; Parker 2017)

3.5 Blockchain

Many unites blockchain with cryptocurrencies, and the reputation of the technology may be a bit negative because of the highly volatile markets of cryptocurrencies. Blockchain has mainly been seen as a tool for the financial sector, but it has recently gained more popularity and many companies, starting from startups to large corporations, are starting to explore the possibilities of using this technology in other areas too. The basic functions behind the technology offer huge potential for value-growth in the context of supply chain management since it can, for example, help to enhance the supply chains' security, the food safety and compliance with the many regulations by offering more transparent supply chains. Blockchain has not yet been utilized widely by companies, but it is expected that up to a

third of manufacturers and retailers are going to use it in product tracking before the year 2021. (Deloitte 2018; Robinson 2018)

There are many definitions for blockchains, but BlockchainHub (2018b) offers a comprehensive definition of the term: *Shared, trusted, public ledger of transactions, that everyone can inspect, but no one can control. It is a cryptographed, secure, tamper resistant distributed database. It solves a complex mathematical problem to exist. A blockchain is the perfect place to store value, identities, agreements, property rights, credentials, etc. Once you put something like a cryptocurrency into it, it will stay there forever.* Blockchain is predicted to create the next generation internet, also referred as Decentralized Web or Web3.

According to King (2018) the power behind blockchain relies on four main principles: distributed and decentralized database, peer-to-peer transactions, transparency of transactions, and security. The first one means that the databases on blockchain are hard to hack in to and they can easily resist outages and manipulation because there is not one certain source. The second principle means that blockchain's role is to act as a trusted layer for the internet in which value is stored, thus, enabling parties to trade without a middleman or intermediary. Blockchain also offers more privacy due to its capability of people transacting anonymously. The third means that all transactions are recorded in the blockchain, which makes it easier to verify them. This is especially important when considering sensitive data since blockchain offers privacy while at the same time it provides other benefits of this technology. The last principle is kind a similar to the first principle since much of the value behind blockchain is laying on the security aspect. Blockchain is secure due to its information being stored in many locations, whilst, traditional methods store all the information in one place.

Blockchain has the opportunity to improve the processes of supply chains in many ways. Korpela, Hallikas and Dahlberg (2017, 4185) mention three possible features of how blockchain could enhance the many activities of supply chains: a public ledger of transactions copied to all nodes of the blockchain network without transaction party identities, a public key infrastructure that encrypts and decrypts transactions and informs parties about the existence of executable transactions with single-time keys, and smart contracts. When it comes to the first feature, blockchain offers privacy by maintaining an

open distributed ledger of transactions while keeping the involved parties anonymous. The ledger is also copied to all nodes of the network. Because of the technology behind blockchain, it would be useless to hack into the ledger due to the data already being public and the information not including any names or bank accounts. By using blockchain a seller or a buyer can inform the counterpart about the transaction and confirm its existence from the public ledger. Currently, typical business transactions involve two parts: a public ledger entry about the transaction and private messaging between the counterparts about their identities, including security keys for transaction data and location. In conclusion, blockchain enables to bypass a third party (e.g. bank) and to execute transactions quickly and with lower costs.

When it comes to the second feature, the public key infrastructure can be used in the form of messaging, for example, in a situation where the initiating party needs to inform the counterparty about the existence and exchangeability of documents that are needed to handle supply chains. This can be done when the initiator sends the counterparty a piece of a public key infrastructure software to decrypt and encrypt the transaction identifier attached to the document exchanged. It does not matter if the counterparty forgets the single key security message because the transaction can be done again. Patel (2017) reminds that there is clearly a need for streamlining international shipments to ease the administrative work and speed up the transport since now shipments from East Africa to Europe can require approvals from up to 30 parties and 200 interactions may occur before the customer receives the goods. Many of these interactions do not just happen between the carriers and shippers, but also between retailers, regulators etc.

Smart contracts are a piece of code running on blockchain network, and they have similar properties as contractual agreements, but they are different than legal contracts. Smart contract can be used by counterparties who agree on the terms which are then recorded as a code on the blockchain. The contract automatically executes an obligation according to these previously coded terms when a triggering event happens e.g. the contract orders more goods when it notices a shortage in the inventory. Due to this automatic execution of obligations, smart contracts do not require any middlemen, thus, they allow rapid transactions with improved efficiency when machines can become purchasers that only execute tasks as all the parties have agreed on. In addition, they create new possibilities for interoperability

between apps located on the same platform. In supply chain management, smart contracts enable companies to track every step of their products as they move across the supply chain while automatically executing many smart contracts during different steps. They also offer more transaction security when compared to traditional contract law. This kind of supply chain management has recently been tested in, for example, by Walmart. (BlockchainHub 2018a; King 2018, Virolainen 2018)

Around 90 percent of consumers mention the transparency of food products as a serious factor that impacts their purchasing habits and they also assume manufacturers to provide the needed information about the food. It is estimated that around 55 percent of consumers are willing to pay a premium for services from those companies that endorse social responsibility. (Deloitte 2018, 6) These said, blockchain can act as an audit trail across a product's lifecycle in supply chains, hence, build trust among the trading partners. Guzov (2017) writes how Walmart's tried to tackle this issue by using blockchain: before Walmart tested the use of blockchain in supply chains, it took approximately one week to trace their food products' original source in case of e.g. a salmonella outbreak. Walmart partnered with IBM to test blockchain together with IoT sensors to track pork coming from China and mangoes from Mexico. In the original country, they tagged the shipments with numeric identifiers, and both signed and logged them at certain points during the journey to U.S. This offered Walmart's employees to see the products' details, such as origin, factory and storage temperatures, in only a few seconds. These tests not only offered traceability but also transparency on how the products were produced and delivered. By conducting these tests, Walmart proved that blockchain can create advantage in supply chain management. Despite the advantages, after the tests their biggest challenge remains to scale this method in the long term. Furthermore, Walmart also has other methods and tests to monitor its supply chains and products' origins than just blockchain.

Blockchain can help to fight crime and other fraudulent behavior. Cargo thefts are a major problem since FBI (2010) estimated that in the U.S. alone, companies face 30 billion USD losses every year and an average theft accounts to 190 000 USD. Furthermore, counterfeiting is also a problem in the global markets. According to Deloitte (2018, 6) counterfeit goods account for over 400 billion USD in trade every year, and around 20 percent of medicines sold on developed countries are fake. Blockchain helps companies to track how the goods

or ingredients are passed through the supply chain and every partner involved in it. This information helps companies to decrease profit losses that occur because of fraudulent behavior and enhance both customer trust and corporate reputation when the origin of products is confirmed. Blockchain's features also offer other benefits, such as its capability of reducing paperwork and administrative costs. It streamlines administrative processes and cuts costs due to the earlier mentioned possibility of efficient auditing. When all kinds of information about the supply chain is available immediately, there is no need to do e.g. expensive research.

Currently, blockchain is a nascent technology, which means that its capabilities and limitations are constantly developed and discovered. Deloitte (2018, 9) finds four challenges facing blockchain today: integration concerns, linking digital to physical, control, security and privacy, and cultural adoption. Integration concerns occur because blockchain requires major changes in current systems and solutions since they are not designed to handle the new technology. To mitigate this issue, companies should create a long-term plan in which they identify the requirements to support blockchain. The second challenge means that the entire supply chain should be renovated by using RFID tags, NFC and other technologies to ensure the information flow from physical goods to digital format. Blockchain will not work sufficiently unless it is provided with plenty of digital information from all over the supply chain. A potential mitigation for this challenge would be to first strategize how to physically track items, and then start adding the digital tagging in the current supply chain. The third challenge regarding control, security and privacy, means that companies are not trusting blockchain enough to add any sensitive information into the technology because there are still concerns about the cybersecurity breaches. Thus, more proofs and ensuring about the safety of blockchain is needed. One solution to help in this matter is to carefully choose the technology solution provider and collaborate with it in order to meet the company's privacy requirements. Also, the technology should always be tested thoroughly first before implementing it any further. Cultural adoption was the last challenge and it refers to the substantial shift to a decentralized network that blockchain represents. This shift requires the buy-in from both its operators and users. The cultural adoption challenge can be solved by socializing the idea of blockchain in the company and with the stakeholders before actually implementing it. This would minimize the possible extra costs and adoption risks.

4 The use of digital technologies in different industries

In this chapter, the results from the empirical study will be mentioned. All the data was gathered from five different companies from which four were companies managing vast supply chains and one was the provider of several digital technologies. The objective was to collect as diverse set of companies from different industries as possible to gain a comprehensive view of the usage of digital technologies in supply chains in general, and whether there were any similarities or differences between the industries. The data was gathered by conducting face-to-face semi-structured interviews with the companies' representatives who are also called as the interviewees. This form of interviewing means that there were a few open questions and topics to guide the conversation towards the desired direction, but other than that, the interviews were more like an uncontrolled conversation about digital technologies in supply chains. The only similar questions asked from all companies were about using the digital technologies discussed in the theory part. However, there were some limitations regarding the chosen companies. All of the companies must have been large companies operating globally with over 100 million euros of revenue annually and they must have had fairly advanced supply chain management. Otherwise, it would have been unlikely that the companies have had even the need to use any digital technologies in their supply chains. The companies are not mentioned by their real names, but instead, the companies are named according to the industries they are operating in.

Table 2. The interviewed industries and interviewees

Industry	Interviewee's position in the company
Telecommunications	Head of Strategic Procurement Transformation and Analytics
Energy	Maintenance & Repair Manager
Paper and packaging	Head of New Digital Business
Aviation	Development Manager
Cloud and cognitive computing	Country Manager

Every company is handled separately in their own chapters. The structure of the chapters will mainly be as follows: first, the company will be introduced briefly and after this comes the assessment of their current situation of using digital technologies in the whole company

versus in the supply chains. Then, their use of the previously mentioned digital technologies will be surveyed, and their views on the benefits and challenges of the technologies are discussed in order to supplement the findings in the theory part. If the companies were not using these technologies, the main reasons for that are mentioned. Lastly, the interviewees' other general views on the topic of digital technologies in supply chains will be discussed. The industries and the interviewees that were interviewed for this empirical section are mentioned shortly in table 2 above. More info about the companies and the interviewees is given in their own chapters.

4.1 Telecommunications

The telecommunications company (TC) is a multinational listed company that operates mainly in the Nordic and Baltic countries and whose history dates back to over a hundred years ago. Its revenue in 2017 was several billion euros and profits accounted for hundreds of million euros while employing thousands of employees. The TC offers a variety of products and services to both B2B and B2C customers, for instance, broadband services, mobile devices, cable television, cybersecurity, gaming and data center. The interviewee from this company was their Head of Strategic Procurement and Analytics who has over a ten-year experience in working among supply chains in, for instance, technology, industrial and telecommunications industries.

The general level of digitalization between their supply chain management and other departments are very much equal, and it is a positive thing according to the interviewee. The management is driving the change towards using more technologies in all areas of the company, including the supply chain management unit. When a new procurement executive was hired a couple of years ago, they began to invest in digital technologies more heavily especially as they implemented data analytics technology in the procurement functions. When it comes to the future of digital technologies, they are about to invest much more in them and improve the level of digitalization in their supply chains. The reason behind this trend is that the TC desires to achieve efficiency and better quality from these technologies since they complete the same tasks much more cost-effectively and with less major errors than humans. Digital technologies were also mentioned to provide better data to support the decision making.

As aforementioned indicated, data analytics is considered as the most important digital technology in the TC and it is the prerequisite for all the other technologies. They say that it provides them more detailed information on almost everything, such as their total spend, and it enables the whole organization to find and dig into the right information faster and easier. The interviewee also mentioned that it helps to collaborate with others when one owns lots of useful data since it is easier to work when everyone has the correct information. Moreover, if one has useful data it motivates the partners to come to you and not the other way around. There rose plenty of challenges regarding the data analytics from which the first mentioned was the quality of data and its granularity. The interviewee meant by this that the company cannot be sure when the used data is sufficient or high-quality, and that the data can be shredded in many different places, which makes it harder to connect all the data together. The second issue comes from the managing the change inside the company and make employees understand that the data analytics technology can be helpful. It was said that there are some employees in the procurement unit who either do not care using the new technology, do not understand it or are reluctant to learn it. Some employees lack the capability of being spontaneous, or in other words, start using the new offered technologies by themselves.

The TC is using many different cloud services in their procurement unit. The benefits they offer was said to be more technical benefits, such as getting more capacity, storage space for data and more flexible systems. Other than these general benefits, the cloud services are not considered as a big advantage specifically in procurement or supply chain management activities. The biggest challenge, however, is the inability to combine data from different cloud services and other systems, which is mainly due to having too many providers who all have their unique solutions. The TC is currently managing a large project that aims to connect all their different cloud services and enable collaboration between them.

Internet of Things is being used in TC's logistics mainly in the format of RFID tags. They help the company to track the items as they move across the supply chains, which in turn, helps to manage and follow the flow of goods. Because the interviewee is not directly working among IoT technologies, no other benefits or challenges were mentioned.

Artificial intelligence is not in use in the TC's supply chains, but they currently have one experiment, or as the interviewee called it, a "proof of concept" where they are testing this technology. By using AI in supply chain management, they expect to receive better data and control over the quality processes, for example easing the current process of using a massive Excel file. In addition, the TC is about to use AI in analyzing and handling bills due to it offering faster processing of this kind of routine work. One major problem regarding the AI was mentioned being the difficulty of creating proper learning data, which should make the technology function as intended. Without a proper data the AI cannot do the tasks it is supposed to do. Other challenges were not faced yet because the company have not used it in a broad scale.

The TC is not using blockchain in their supply chain operations, nor they have any plans of implementing it in the near future either because they do not see it as a necessary technology. Only the smart contract aspect could be deployed someday. However, they acknowledge the fact that blockchain can decrease the number of middlemen, but the TC does not currently have that many middlemen to start from, so they do not need to cut them. The interviewee sees blockchain as a more valuable technology in the retail industry than in telecommunications since the originality of products is more important to trace in retail business. In summary, the TC understands the concept of blockchain very well, but their current operations do not require using it.

There are a few approaches on how the TC implements new technologies in their operations. Firstly, they test the new technologies in small formats with the help of their IT department to see whether the technology is useful or not. When it comes to the employee aspect, the company wants to implement the new technologies in all of its employees' daily routines. The management is trying to achieve this by encouraging the employees to use them, and by monitoring the level of usage of the technologies. In addition to implementing these technologies in the daily routines of employees, the management also wishes to find new problems with these actions. The company seeks and implements new technologies only when they see a need for it, for example, a process that could be improved significantly. This means that they do not implement any technologies if they do not have a real issue to be solved. However, they can test new technologies in smaller formats without a relevant need for them in order to see if the technology could be useful anyhow.

4.2 Energy

The Energy Company (EC) is a large company that operates in the Nordic countries with several billions of euros in sales and hundreds of millions of euros in profits annually. The company does research on and develops economically viable and environmentally sustainable energy solutions. Its offering includes direct sales of energy solutions to both private and corporate customers, many sorts of renewable energy solutions, and retail stations. In the last segment the company has approximately a 20 percent market share in the Nordic Countries, while employing around one thousand employees. The interviewee from this company is the Maintenance and Repair Manager who has worked among the energy industry for almost three decades in many roles across the supply chains, for example, as a sourcing manager in the EC.

The level of digitalization in EC in general is slightly more advanced when compared to the level of supply chain management. According to the interviewee, the company has mainly been using the same digital technologies for the past 10 years in their supply chains mostly because there is no reason to invest in them. A couple of reasons were mentioned for not having to invest, and the first were the stable industry and the second being the project-like business. Energy business has not changed very much during the past years, which means that the EC has not been required to find competitive advantages from digital technologies. The company's supply chain department mainly handles many large projects across the Nordic countries that can differ from each other a lot, thus, requiring different kinds of tools since the same technologies may not be applicable to all projects. When the company cannot use the same technologies in every project it is difficult to invest in any major technology in the long term. The future of the company is also seen similar and no new technologies are in consideration to be implemented, unless, a major project requires acquiring one. It was mentioned that the EC only acquires new technologies if they see a real need for it. In other words, the company does not invest in technologies unless they have a real problem to be solved. The lack of know-how is seen a challenge when considering new technologies, which means that the employees may not be aware of how to use them or what the benefits are.

The EC has a centralized IT department that handles all the digital technologies for the entire company. This IT department is currently using cloud solutions in some extent, but they are clearly about to invest more in them in the near future. The EC is not using data analytics in their supply chains and the main reason for this is that they do not have many suppliers to be managed, hence, not needing data analytics to provide them in-depth information. IoT technology was mentioned maybe being used in the logistics in the format of RFID in order to track the goods. However, the interviewee was not sure about this technology since the logistics are handled by other employees. When it comes to artificial intelligence and blockchain, the company is not using them, and no possible benefits, challenges or future views were known. Despite not using the previously mentioned digital technologies, the company is using Excel in many ways, such as creating contracts and managing its supplier base. Excel and other few traditional systems were considered to handle all the necessary tasks efficiently.

4.3 Paper and Packaging

The Paper and Packaging Company (PP) is a large and listed company with sales over several billions and profits over hundreds of millions of euros annually. Their headquarters locates in Finland, but they operate globally and have tens of thousands of employees in over 20 countries. The vast majority of sales is generated in Europe where also the majority of employees are situated. The PP has a comprehensive offering, which includes renewable solutions, consumer boards, biomaterials, wood products, packaging solutions and paper. Their offering has not been long this broad since only ten years ago almost 75 percent of the total sales accounted from the paper segment, but last year it accounted less than 30 percent, whereas, the other previously mentioned segments have become significantly more important than before. The interviewee is the Head of New Digital Business who has previously been working for over twenty years among several digital technologies, such as IoT and industrial internet. The interviewee's current role is to identify, establish and grow new digital business for the PP.

The PP is heavily focusing on finding new opportunities for digitalization in their entire value chain. Digital themes include, for example, smart operations, transparency in supply chain, digital customer experience, and new smart products and services. The top

management of the company is driving the growth of digital solutions and the innovation culture is growing fast. There have been many new approaches during the past few years to drive the growth of digitalization, such as a digitalization fund, startup accelerator program and collaboration with external business partners. The digitalization fund is used to invest PP's employee-initiated projects, which means that every employee is encouraged to invent something new and the best ideas receive funding. The startup accelerator program, in turn, is an executive program inside the company that develops understanding and knowledge within the PP's strategic competencies and cooperates side-by-side with real startups to develop new commercial solutions in the area of digitalization.

Today, there are 62 projects in progress in the whole company regarding new solutions for digital technologies and the top three most commonly used technologies in these projects are Internet of Things, advanced analytics and machine learning. The investment for these projects comes from the digitalization fund. The supply chain department is not leaving behind from this growth since there are currently 30 projects in progress solely among supply chains. Despite having many projects in progress, the interviewee mentioned it not being easy to implement and develop new technologies for this department due to them having so many old technologies and systems hampering the progress. In other words, the process of improving the level of digitalization in the supply chains is still in its pilot phase because this improvement trend is only a few years old.

The PP is using data analytics in their supply chain management and procurement. Some benefits were mentioned, such as data analytics connecting data from various ERPs, which provides more transparency when all the data is at one place and easily visible. Also, operations become more intensified due to employees being capable of handling tasks quicker and reacting in time to any problems, such as sending information to a client about a delay before it acknowledges the problem and sends a complaint. By being capable of reacting to problems faster, the PP is able to avoid costly disruptions. Four challenges regarding data analytics were mentioned from which the first one was the problem of utilizing the huge amounts of data since the company may not even know where to start gathering data. The second one was the lack of know-how on utilizing this technology properly and effectively. The third challenge was the lack of time to start developing and implementing a new technology, and this is especially a problem in nowadays when most of

the employees are loaded with other work. The last challenge was also a deficiency: many people lack the courage to start using the technology or even developing one.

Cloud services are in use in the PP's supply chain activities. The services are built on top of Azure and they are constantly being developed further. The interviewee mentioned the most visible benefit being the increased visibility to customers. This means that by incorporating the PP's cloud solutions to the customers it becomes easier for the customers to digitalize their supply chains as well and participate in the actions more comprehensively. The challenge of cloud services is somewhat the same as with data analytics: the company has a lack of understanding and know-how on what to do with the data. However, the company understands the possibilities of cloud services, but the actual implementation and utilization steps are the hardest parts.

Internet of Things is in use in the PP, but mainly in the logistics in the format of RFID that enables tracking and tracing of goods. RFID was said to be a very popular technology in tracking especially among the wood materials, and they help to authenticate the originality of the products, thus bringing more transparency in the supply chain. The company is also using drones to help, e.g. source wood and calculate the amount of wood materials in the open-field inventory in the factories' yards. This calculation process was previously done by humans and it took several days to calculate the huge inventory, but now the drones can do the same task within hours with the help of sensors and cameras included on the drone. In addition, IoT technologies was mentioned enabling new business models that ensure the availability of products and a sufficient level of inventory in order to prevent an out-of-stock event. The challenge of IoT is to determine whether to use an active or a passive IoT technology since active is much more expensive than passive. In other words, it requires a good understanding of both the business processes and the technology itself to know which one to utilize and invest in. Also, IoT is a technology that is evolving quickly, which creates a challenge for the company to keep up with the constant development.

When it comes to artificial intelligence, the PP is having many experiments on using and scaling it, but their current AI-related technologies are mostly limited to chatbots and virtual assistants. The interviewee sees three benefits related to using AI. The first is that it helps in problem-solving due to being capable of solving problems, especially routine tasks, faster

than humans. The second benefit is a result of the first since when humans do not need to solve routine tasks they can use this released time to do other more lucrative tasks. The third benefit is also a result of the processing power of AI technology, which improves the customer satisfaction due to receiving faster service. The challenges, in turn, were considered being the hype and the potential use. The interviewee refers with the hype on the fact that markets are giving so much exaggerated marketing information about the functionality of AI that it makes it difficult to perceive the real potential and usability of the technology. The second challenge means that the company has not yet found that many potential places or areas to implement the AI in.

The PP has done some research on how to possibly utilize blockchain in their operations, and they currently have a few experiments in progress regarding this technology. All the benefits are not yet one hundred percent clear because the experiments are still in their early steps. However, the possibility of tracing the originality of products and the smart contracts were mentioned to bring advantages in the supply chain management. Blockchain's one challenge is that there so many providers offering various types of this technology, which hardens the process of finding the suitable technology. Also, as previously mentioned, the capability of tracing back the originality of products is a benefit but also a challenge because, according to the interviewee, the originality of products can be clarified with other methods as well. Other challenge is that the utilization and implementation of blockchain is difficult due to it requiring the participation of the partners, such as clients, to function properly. Hence, if all the partners do not participate in this technology, its usability can weaken. The last challenges mentioned were the big hype and rapid development. Similarly to AI, markets are providing plenty of information about the benefits and opportunities of blockchain, but the truth can be different. The rapid development of blockchain technology also poses a challenge because today's technology can be outdated after one year, which makes it difficult to invest in it in the long term.

The PP has a few general solutions which it has used to solve these challenges. Firstly, it keeps the employees' responsibilities as clear as possible in order to prevent them doing the same tasks at the same time. Secondly, they are driving and encouraging the change towards digitalization in the whole company starting all the way from the chief officers. Thirdly, they desire to keep the relationships tight with all the stakeholders and partners to enhance

collaboration and communication. In terms of digital technologies, the company sees its future very bright since both the development process and organization are clear, and they are putting much effort in implementing new digital solutions. According to the interviewee, the most important aspect to consider now and in the future is to first understand the business processes and their needs, and then think about possible new technologies. The reason for this is that there are so much technology available in the markets that the PP must first be sure that they fit their needs or even require new technology. The company does not implement new technologies right away in full scale, but instead, it uses the proof of concept method when it considers implementing new technologies. If the technology seems functional in the smaller scale the company can implement it after the trial period.

4.4 Aviation

The aviation company (AC) is a large and listed company with over a billion euros of revenue annually. They operate with over 50 airplanes that fly to over 100 destinations worldwide. They have thousands of employees and the history dates well back to earlier half of the 20th century. For this company, the interview was conducted with their Development Manager who works in the supply chain management department. The interviewee has over a decade of experience in leading procurement activities in many different technology-based companies. Currently the interviewee is responsible for developing procure-to-pay activities.

AC's overall level of digitalization is good, but the supply chain side is not yet as advanced as the rest of the company. For example, the tools and systems used in the supply chain management are not as modern as the ones other departments are using. The company has invested heavily in modernizing their general digital technologies and digital outlook, but the achieved profits are not strongly visible yet. However, a few years ago they begun to invest more in the digitalization of the supply chain management unit as well. The company changed its organization by employing plenty of new employees equipped with advanced digital skills. There were many reasons why they did this kind of transformation, but one major reason was that their networks (partners, customer base etc.) kept expanding, which sort of saying forced them to find new solutions to keep up with the development. Other major reason driving the development forward were the executives who wanted to improve the use of digital technologies in the AC. They already have had some digital tools available

in the SCM unit for over a decade, such as electronic signatures and the use of mobile devices, but they have not been very popular until recently.

The future of the digitalization technologies looks brighter than the past in the AC. Their objective is to utilize many new technologies and make the procurement processes as autonomous as possible, for instance, in competitive bidding and billing that could be handled without the involvement of humans up to a certain point. Also, they are investing in mobile payment systems especially because they are operating in Asia where this technology is popular. This future development of digitalization is due to at least two factors: AC seeks for new business opportunities and revenue, and desires do enhance the customer experience and satisfaction.

AC has used data analytics for several years. According to the interviewee, this technology has offered them many advantages and will enhance the supply chain operations even more in the future. By using data analytics, they can more easily access comprehensive data on their suppliers, e.g. the credit rating, which helps to categorize and understand the supplier base more thoroughly. Furthermore, this technology allows the company to “drill into” the data in more detail because all the necessary information and data are in one place. Data analytics enables faster processing and browsing through the vast amounts of data the company has. The data processing and browsing becomes faster due to the technology not requiring as many middlemen or admins as before. When the information and data are more easily available and better organized the AC mentions it being easier to detect the bottlenecks in its supply chains and acknowledge how to enhance the processes. In addition, when there are more data available the decision-making is more efficient and fact-based, and the attention focuses on the right tasks instead of those tasks that “the loudest” employees notify. When it comes to the future of data analytics in the AC they are planning to expand its usage and invest more in it. They are particularly seeking to achieve better utilization of categories, e.g. what kind of contracts could be applied with certain type of suppliers.

The usage of cloud services is currently at a high level in the AC, and all the future systems are planned to be based on cloud services. Currently, approximately 80 percent of their systems are based on cloud computing technologies. They consider cloud services to bring a major benefit especially in negotiation situations where all the parties can easily access

and see the same information from one place. In other words, they consider that cloud services offer more data with less effort required to search it. Cloud services help the AC in their supply relationship management, which means that it is easier for them to manage their suppliers.

IoT is particularly in use in the cargo handling department and in logistics where they use RFID tags to track the shipments. IoT technologies have not been long in use in the AC since they started renovating the cargo handling just recently. The company sees this tracking technology as a great solution for creating efficiencies and improving the reliability of the shipping. The biggest challenge regarding IoT was said to be the challenge of doing something new, which means that it takes some time and practice to implement the new technologies and ways of working. Other places for the usage of IoT than the cargo handling was not yet seen necessary.

Artificial intelligence is not yet in use in the AC. However, the interviewee acknowledged the opportunities of AI: the representative mentioned that it would enhance the analyzing of data due to its advanced capability of creating useful data from a large amount of information. This would especially be important because they consider that resources are wasted if humans try to do this same processing. Moreover, as previously mentioned they are using data analysis tools, and AI could help them to take better advantage of those tools. Machine learning is not currently in use in the AC either, but they are considering using it in the future. The interviewee also acknowledged its possibilities since it was mentioned that machine learning would help to process the large masses of data.

Blockchain is not in use in the AC. The company has couple of reasons why they are not using it, for example, the future of the technology is the most uncertain of all the technologies, which makes its usage harder. Other reason is that they want the money straight in their own bank accounts rather than as tokens or cryptocurrencies. Despite not using the technology, the AC sees blockchain as a solution to increase transparency in their supply chains.

The company faces a few overall challenges regarding the digital technologies. Firstly, the interest towards the new technology projects decreases if there are too many projects

ongoing at the same time and they take too long to implement or show results. Secondly, the transformation can be slow due to the fact that the AC cannot manage many technology implementation projects at the same time. It is better to focus on one technology or project at a time in order not to lose interest or put enough efforts in it. Thirdly, it is a challenge of knowing how much the new technologies should cost and how much the AC should invest in them. Some technologies are so new that there are limited number of alternatives available, which makes it harder to compare the prices and contents. Also, it is hard to estimate how much money the company should be invested in certain technologies because the transformation towards more digitalized supply chain is still a fairly new approach and the return of investments are unclear. Despite the challenges, the executives are constantly promoting the new technologies to be used in their business and are aware of the possibilities digitalization has to offer.

The interviewee refers to their company with the term “state of the art”. This means that the company desires to take advantage of the most recent technologies available in the market. They have at least two approaches when dealing with the implementation of new technologies: outsourcing and proof of concept. Outsourcing means that the AC prefers to develop and search for new technologies from outside the company. Proof of concept, on the other hand, is a common practice that the AC is practicing, and it means that before implementing the technology entirely they first test in a smaller scale to see whether it works or not. This prevents putting too much resources on some technology that does not function properly.

In addition to all the previously mentioned, the interviewee thinks that the digital technologies should be more visible and used in the supply chains. The current situation is not enough, and the company should develop its technologies even further. It was also mentioned that a major issue is to understand and learn how to keep up every employee with the technological development. Some employees are not willing or capable of internalizing the new methods the same phase as the most technology-savvy employees.

4.5 Cloud and cognitive computing

The cloud and cognitive computing company (CC) differs from the previously mentioned companies due to it being a provider of digital solutions, instead of their user. Therefore, the interview was conducted in a slightly modified way. The interview focused on the company's perspective on what the challenges and benefits of digital technologies are in general, how companies use them, are there differences between industries etc. In other words, the interview did not focus on the CC's use of digital technologies, but what they think their customers feel about and do with them.

The CC has a long and colorful history of offering various digital solutions to both B2B and B2C customers. It is a publicly traded company and it currently operates in almost every country of the world, while employing hundreds of thousands of employees. Last year, the company generated tens of billions of sales with around ten billion USD of profit. Their product portfolio ranges all the way from financial services to blockchain, and all the technologies discussed in this thesis include in their offering. They have experience in providing services and products to all sorts of industries including the public and private sectors. The interviewee is the company's local Country Manager in IoT technologies with over twenty years of experience in working with various IT solutions. The interviewee has also worked among sales for most of the career, which contains selling and outsourcing digital solutions to companies and other organizations.

The first topic was to discuss the general level of digitalization of supply chains in all industries. According to the interviewee, there are huge differences between industries on how they utilize digital solutions in their supply chains. For example, the utilization level is high in manufacturing industry, whereas, in construction industry there are hardly any digital technologies in use. The reasons manufacturing industry is applying these the most is that they face a lot of competition and the benefits are easily visible. Construction industry has not seen the need for digital technologies because the industry is somewhat stable and a bit old-fashioned. Other reason for not implementing digital solutions in business is that the executives are reluctant to do any major changes. This is especially the case when dealing with older executives. Logistics was mentioned to be on average level in their level of digitalization when compared to others. When it comes to procurement in general, it falls

behind to logistics and many more industries or departments in this category. The interviewee sees that there are two kinds of digitalization: optimizing parts and renewing business. The first one shows the benefits or profits almost instantly and the second one takes a longer time to show its results because the scale of the change is larger. Companies can apply both of these approaches, but in that case, the first one mainly supports the second one's development.

When considering the future of digitalization in supply chains, the use of different technologies is expected to grow. The interviewee sees three major factors driving this growth. Firstly, companies desire to become more cost-effective and hope that digital solutions will enable this change. Flexibility is the second factor since many industries have faced difficulties when trying to alter their business. The third factor is that the overall development and competition in the markets forces companies to invest in technologies and keep up with the trend in order to stay competitive. The interviewee also mentions a challenge from the digital technology's provider's point of view: data that help the companies to operate more efficiently can be created almost endlessly with the current technologies, but the demand for them is uncertain due to the technologies being so new, which complicates their pricing.

During the recent years, the utilization of data and its enrichment have been the most popular forms of using digital technologies in general. Data analytics offers plenty of advantages and ways to improve business processes. It, for example, assists companies to make the right decisions based on facts due to it providing more comprehensive reporting of both historical and current situations and activities. Data analytics can be predictive, which means that it helps to predict the future events. IoT and machine learning are two technologies that strongly link to this capability of predicting future events since IoT helps to detect the physical events and machine learning learns to predict from the data gathered by IoT. Prescriptive data analytics is the next step further from predictive, which helps to decide the best options of actions for the future events. For instance, predictive data analytics notices that an elevator is about to break in the next few months and prescriptive helps to choose the correct procedures to fix the elevator.

Despite the many advantages of data analytics, it also faces challenges according to the interviewee. The quality of data was mentioned to affect in all industries. If the historical or current data is not sufficient enough the predicting capabilities diminish because in order to create trustworthy forecast there must be reliable and high-quality data available. For instance, the documentation of fault history created during operational actions can often be unreliable or insufficient. Other challenge mentioned is that companies may not always have existing data that they could analyze right away after implementing the new data analysis technology. Hence, it can take some time to gather enough high-quality data before receiving any results. Furthermore, there are challenges in managing the existing data, which means that companies are not always aware of where the data is being stored and how it is being used. This is often caused by the lack of department or employees that are responsible for the data management.

The popularity of cloud services is increasing in all industries, especially the user-specific and customer relationship management cloud services. Nowadays, most of the cloud services are maintained by the service providers, and the availability of different services is expanding since the number of cloud service providers is growing rapidly. Agility was mentioned as one of the most important benefits of cloud services, which refers that clouds enable fast transferring of data all around the globe. Other benefit is that clouds offer security, but however, there are variations between opinions among different actors on the security issue. Cloud services are good services from both the providers' and customers' point of views because their price tags are easily visible and predictable according to the required functions. The CC mentioned that there are not many licensing problems when companies are using cloud services since this can be a problem with other systems. Despite the many benefits of cloud technologies, it also faces challenges, such as they are easier to implement in some industries than other due to regulation differences. Financial industry and public sector are two common examples of difficult industries to utilize cloud services because they are so heavily regulated, which makes it more complicated to bring in new technologies. Cloud is mentioned to ease the transferring of data, but even though the new advances in technology, even cloud computing faces latency problems when trying to transfer data as fast as possible. The last challenge of clouds is that they are often confused being cheap. This is not actually true, and it can be surprising to many customers considering investing in that technology due to having to pay more than expected. In other words, the

technology provides services in a new way, but the costs of delivering the same service as the customers are used to receiving are not significantly lower than before with the older technologies.

IoT technology offers companies great opportunities to increase their operational efficiencies, which affect in all industries all the way from real estate industry to logistics. IoT enables companies, for instance, to increase their total capacity in manufacturing and aid the employees to reach improved productivity levels. The technology also enhances the predictability due to receiving more data. Therefore, data analytics and IoT are two technologies that go hand in hand because IoT helps to gather data that data analytics then processes. The interviewee sees three significant challenges in IoT from which the first being the unclear profitability. This means that companies are not sure whether the sensors and devices connected to the internet will pay themselves back or other ways improve the business processes enough to invest in them. In addition, there are some industries that do not need such a technology or industries that do not find enough proper targets to implement the IoT in. Lastly, companies can sometimes find themselves overthinking the functionality of IoT technologies instead of thinking how to actually solve a problem with the technology, thus, failing to gain any value from it.

Artificial intelligence is currently a trendy and much “hyped” technology in the markets, but many companies are just beginning to acknowledge its possibilities. AI also connects to the data analytics since the latter technology cannot function at its highest potential without the help of AI, machine learning and deep learning. Moreover, AI allows to better combine structured and unstructured data from various sources when compared to humans. There are no clear approaches of using artificial intelligence since the most concrete solutions of AI in business today were mentioned being chatbots and video analyses. Artificial intelligence’s biggest issue is the thorough understanding of the whole concept in most companies. What this means in brief, companies are expecting too much from the existing artificial intelligence solutions, which is mainly caused by the exaggerated marketing of AI all over the markets. In addition to this, the true understanding of AI and its capabilities are somewhat lacking among business executives.

According to the interviewee, blockchain is not yet a very commonly used technology, but it will offer many new capabilities of improving supply chains in the near future. The technology is so new that the CC started offering blockchain solutions for about a year ago. Blockchain, similar to other technologies mentioned in this thesis, can improve supply chains in several ways when it becomes more popular and usable. It allows companies to streamline and digitalize their supply chains, confirm the originality of products, lower transactional and administration costs, and decrease middlemen. Despite the pros, blockchain's opportunities cannot be utilized if all the middlemen or partners involved in the supply chain decide to use it. Furthermore, markets in general are not yet ready to put blockchain into practice because there are still some open questions to be solved, such as how to bring all the middlemen, and even competitors, under the same technology and use the blockchain with them smoothly.

5 Discussion

In this section, the information from the theory and empirical parts will be combined, and thus, analyzes will be made whether the theory supports the empirical findings or not. Furthermore, analyzing regarding the empirical findings is being done, for instance, the differences and similarities between different industries. The aforementioned topics and some other issues will be discussed with the help of the research questions mentioned in the earlier part of this thesis.

The first main research question was: *What kind of major digital technologies have recently emerged or are about to emerge in the near future?*

There are multiple digital technologies available in the markets, but only five major technologies were chosen to be discussed for this thesis mainly due to them being capable of providing a broad scale of different benefits. Also, these technologies have reached their development stage in which they can really be used to enhance business processes. Data analytics was the first technology mentioned because it acts so closely together with the other technologies by providing sufficient data to them and processing the data received from them. Data analytics is also a common technology nowadays among companies. Internet of Things was the second technological solution to be discussed, and it is expected to be a very popular technology worldwide during the next few years.

The third technology was artificial intelligence and its sub-technology machine learning. Artificial intelligence is a multiple decades old term and technology, but only recently its development has been somewhat promising, and it is beginning to recognize actual artificial intelligence. However, there are much exaggerated marketing about the capabilities of AI and that was also one reason why it was discussed in this thesis to understand whether these claims are true. Machine learning includes in artificial intelligence, but it processes the data in its own way. The fourth digital technology was cloud computing and cloud services, which are gaining much popularity among companies seeking efficiency. There are many different variations of cloud services, but the most common one is the SaaS, Service as a Solution. The last technology was the most recent one from all of these: blockchain. This technology is still in its earlier stage of development and there are not many applications

been done in supply chain management yet. Despite this, its future benefits are very promising, which was a one major reason for the selection of this technology.

What are the benefits, challenges and views of future of these technologies?

The first sub-question's purpose was to supplement the first main research question. Because there are so many technologies and all of them have various benefits, challenges and future views, they are represented in a table format to save space. All the information is mentioned briefly in the tables and more detailed information can be found from the theory and empirical section. In conclusion, the information for the tables are gathered from both the interviewees and literature.

Table 3 Summary of data analytics

Benefits	Challenges	Future views
Increase in profit, especially in retail industry with 60 % increase	33 % of data is useful, but 0,5 % is utilized	Similar affect as ICT had in 1990's and 2000's
Cost & time reductions	Companies discard useful data	The amount of data will approximately double annually
New product development	Data locality & latency issue	50 times more stored data from 2012 to 2020
Optimize and personalize offering	Fault tolerance	
Smarter and fact-based decision-making	Security	
Determine faults, root causes and frauds	Heterogeneity of data	
Instant results		
Descriptive, predictive, prescriptive		

It can be said that data analytics offers several benefits if it is utilized properly, and the challenges are all solvable. This technology will gain more and more popularity in the near future since it offers so much competitive advantage and acts as a platform for all the rest digital technologies. Data analytics would not have these many benefits unless the other technologies would not be harnessed to collaborate with it. For example, IoT provides data and artificial intelligence together with machine learning makes the data analytics process much more efficient. Cloud services, in turn, offer a solution for the problem of vast amounts of data since companies can store more data in cloud platforms and access it easily from them than with traditional storage systems. Data analytics does not solely offer benefits at the present moment, but instead, offers solutions to manage the future events due to its predictive and prescriptive capabilities. In brief, data analytics offers companies more fact-based information about their business, and therefore eases the optimization of processes.

Table 4 Summary of Internet of Things

Benefits	Challenges	Future views
Predict faults and maintenance needs without humans and from distance	Some benefits still unavailable due to insufficient technology	10 billion devices connected to the internet in 2015, but 34 billion in 2020
Extend a good's life cycle	Many industries not yet ready to implement IoT	6 trillion USD will be spent on IoT worldwide
Increased agility	Lack of skilled workforce	Public sector in EU will start to endorse IoT
Worldwide tracking of goods	Expenses of utilizing IoT expected to rise	Voice command feature
Better awareness and transparency of supply chains	The number of providers diminishes	Integration of companies' IoT assets
Inventory management enhances		Blockchain and IoT collaborate
Security		
Cost savings through automation		

As seen on table 4, there are various benefits achievable through using IoT technology. Many of its features and benefits create new advantages, e.g. IoT offering better trackability of goods, which enhances the inventory management and increases agility. The process of mass implementation of IoT is still lacking due to a few major issues, like the lack of know-how and slow development of large companies due to their heavy legacy systems. The current form of IoT does not seem to be sufficient for companies since they need to make other technologies collaborate with it, which increases the expenses of implementing IoT. Also, when the requirements diversify the number of providers capable of offering these many solutions at once diminishes, hence lowering the competition and availability of different variations of IoT technologies.

Table 5 Summary of artificial intelligence and machine learning

Benefits	Challenges	Future views
Enhanced quality	Are the current solutions automation or intelligence?	Best applications are still to come
Lower costs	Lack of computing power	Half of global GDP growth will result from AI
Increased agility	Narrow capability & not human-like thinking	Unequal growth and use of AI worldwide
Better CRM	Lack of understanding and professionals	Retail, financial services and healthcare industries benefit the most
Demand planning and inventory management	Expectation do not meet the actual gains	Large investments when compared to companies' total IT budgets
Transportation network design		
Elimination of the bullwhip effect		

The information regarding AI and machine learning are put together in table 5 because they are often considered as the same technology and they have the same pros and cons. The benefits and challenges are also quite similar to the previous technology, IoT. The main issue

in artificial intelligence seems to be that it is commonly mixed to pure automation, and only a few people realize the true potential and capabilities of this technology. When one reads about AI, it quickly feels that it is a very advanced technology and that computers could actually think like humans, but the truth is different. Companies are not actually using the technology the way it is expected to be used, and the benefits are not that good as the markets let one assume. The potential of AI and machine learning are huge in the future when there is a lot more computing power available and the technology itself is more advanced, but for now, they remind more of automation, robotization or traditional data analytics. Moreover, the current artificial intelligence can handle many narrow tasks, but it lacks at least the capability of generalizing. Despite the doubts, AI could easily bring many advantages to supply chain management and enhance the current processes, and maybe this is the reason why companies are investing in this technology so much.

Table 6 Summary of cloud computing

Benefits	Challenges	Future views
Increased speed	Additional features can be expensive	80 % of supply chains will have at least portions connected to cloud by 2020
Global scalability	Implementation and data transfer can be expensive in shorter & smaller projects	Especially retailers can benefit greatly
Eliminates capital costs	Many smaller providers from which some may not be that trustworthy	
Operational reliability	If internet connection breaks the cloud becomes useless	
Increased productivity	Security & privacy issues	
Performance through constant upgrading	May be hard to find a suitable provider	

As table 6 summarizes, cloud services are becoming more and more popular among companies and in their supply chains. Clouds allow companies to connect all the parts of

their supply chains under one system, which eases the management of operations when everyone sees the same information across the supply chain. Cloud services also release the user from the upgrading obligation since the provider handles all software's upgrades and manages the physical elements, such as hardware and electricity. However, one easily understands that this absence of physical elements and the need for own IT department upgrading the systems mean that cloud services are cheaper to use than the traditional company's own systems. Using cloud may not be any less expensive, especially when several add-ons are required, and the current systems need to be integrated with the new one. Smaller providers can create cloud solutions quite easily nowadays, but the actual know-how of implementing and integrating it to work seamlessly with the customer's older methods is an entirely other task, which can be too difficult to accomplish for the smallest providers. Therefore, it is necessary for the user to be thorough about its own requirements and the provider's capabilities.

Table 7 Summary of blockchain

Benefits	Challenges	Future views
Security against cyberattacks and crime	Other technologies can accomplish many same tasks	Other industries than finance sector will start to use blockchain
Transparency, trackability and audit trail	Integration problems	One third of manufacturers and retailers use blockchain by 2021
Streamlining of supply chain	Renovating the entire supply chain to link physical to digital	Next generation internet: Decentralized Web or Web3
Food safety	Concerns about the security	More proofs of the functionality needed
Automatic execution and compliance of obligations	Cultural adoption	
Privacy from being anonymous		
Lower costs when fewer middlemen		

Table 7 shows the many advantages and potentials of blockchain, but positives do not come without negatives. The main problem with blockchain is that the technology is so new that there are hardly any actual use-cases and the technology itself is constantly developing. In other words, the technology is far from reaching its mature stage. However, there are a few signs especially from the financial and retail industries that this technology is capable of providing workable solutions in real life business situations. When this technology is being developed well enough, it becomes widely adopted in supply chains, and the security aspect can be guaranteed, the gains can be expected to be significant in the future.

All in all, these five digital technologies have many similar benefits, challenges and futures. They also have the ability to offer support to each other in functioning as a whole in order to enhance the supply chain management greatly. The popularity and usage of these technologies is not yet very common among supply chains, but the near future looks bright since many new solutions are being adopted and developed gradually. When these, and many other technologies, are being implemented the operations are expected to transform and become more efficient. This way SCM indirectly offers benefits to the whole company.

Do companies in different industries use these digital technologies in their supply chains, and if so, in what ways?

There were five different technologies discussed in this thesis and five companies interviewed representing different industries. The technologies were data analytics (Data), Internet of Things (IoT), artificial intelligence and machine learning (AI & ML), cloud computing (Cloud) and blockchain (Block). The industries interviewed were telecommunications (TC), energy (EC), paper and packaging (PP), aviation (AC), and cloud and cognitive computing (CC). The objective was to determine whether these companies use the digital technologies in their supply chain management or not. Table 8 below shows the results where “X” means the company is using the technology, “≈” means there are some tests being done or will be made shortly, and empty cell means the company is not using the technology.

Table 8 Five companies and their usage of digital technologies

	Data	IoT	AI & ML	Cloud	Block
TC	X	X	≈	X	
EC		≈		X	
PP	X	X	≈	X	≈
AC	X	X		X	
CC	X	X	X	X	X

As seen on table 8 the most common technologies were cloud services, IoT and data analytics. These results were anticipated since, as discussed in the theory part, artificial intelligence and blockchain are not yet very popular technologies in SCM. IoT offers many benefits for companies, but despite this, the most common form of it in these companies were the RFID tags in their logistics to help them track goods.

The CC has an “X” on all technologies because it provides all of them for its customers. This result is intriguing because the company is a well-known company and it operates in the same markets as the rest of the companies in this list. Yet, its offerings, mainly AI and blockchain, have not reached the other companies by now. The main reason behind this might be the novelty of these two technologies and they not yet being well-developed enough. If considering the user-side of this company list, the PP is the most advanced user of digital technologies in their supply chain management with only the AI and blockchain lacking a full implementation. The TC and AC were the second most advanced companies with a slight difference of TC currently testing the AI. The EC, however, was only using the cloud services in some extent and possibly the RFID tags in its logistics.

In general, all most of the companies and their interviewees are well aware of the modern digital technologies and how they could affect their supply chain management, even though, they are not using all of them. The development of implementing new digital solutions to SCM seems to be accelerating while the companies are currently putting much more effort and resources in them than before. This trend supports the findings mentioned in the theory part about the switching role of SCM and digital technologies and their progress towards a more strategic role within companies. Table 8 could, with high probability, have many more

“X” marks on it if this study would be done again after a few years. This because many technologies are not yet ready to be implemented in a broad scale and the general development takes time.

The cloud and cognitive company (provider) and the rest of the companies all have similar types of opinions about the technologies, such as regarding the benefits and challenges. The CC mentioned that there are huge differences between industries on how they use digital technologies in their supply chain management, and the findings from the theory and empirical sections all support this claim. Despite the many common features between the theoretical and empirical sections, many of the companies are not using the technologies at their fullest potential since the technologies could be used in much wider scale than the companies are using them currently. This is especially the case with IoT that is mainly being used in the format of RFID to track the goods.

If the technologies have not been used yet, what is the reason for that?

Before any in-depth analyzes, it is necessary to notice that the industries the companies are operating in vary from each other and therefore there are different needs for digital technologies for all of them. This is especially the case with the EC who did not see any need for implementing new digital solutions to its SCM due to their business being stable and SCM fairly simple. They have also been capable of managing their supply chains well with the older and more traditional methods. The other companies can benefit more from the digital technologies due to the intense competition and switching preferences among their customers. For example, the aviation company needs to find new solutions to be more productive since the competition is really tight in that industry. Furthermore, the paper and packaging company can no longer rely on its older products to provide a sufficient amount of sales and profits in the future because the demand of paper is decreasing worldwide. This development encourages them to find new sources of income and enhance their operations with the latest digital technologies. The fact that many of the interviewees said their companies mainly implement new technologies only when they see a need for it, support the aforementioned.

Many of the interviewed companies had started their digital transformation progress only a couple years ago. One reason for not taking an initiative towards digital technologies earlier was the lack of technology-oriented executives and employees. Some of the companies had made many changes in their organizations by dismissing their older staff and hiring new employees with fresher knowledge of digitalization. Regardless of these organizational changes, companies are still facing the lack of professional employees equipped with advanced technological skills. According to the theory, the lack of technology-savvy employees had a very big impact on the lack of development, however, the interviews did not support this finding. Of course, the interviewees mentioned the lack of coders and programmers etc., but they emphasized more the willingness of using new technologies. Also, the lack of time to concentrate on new digital solutions was an issue, which was not found in the theory section. In other words, companies seem to understand the role of digital technologies, but they lack the need, will and/or time to endorse them. Some interviewees even said that they have too many projects in progress at the same time or they take too long to show any concrete results. These both aspects were said to hamper the interests towards the digital transformation.

There are several technology providers with unique solutions in the markets. This makes it hard for the companies to find suitable solutions specifically designed for their requirements. As the interviewee from the paper and packaging company said in the interviewee “there are plenty of technologies available out there, but we need to determine our needs first.” Moreover, the theory mentioned that it can be difficult to find a reliable provider since many of them are startups without any guarantees of success. A similar problem related to this issue are the current systems being used in SCM because the new solutions do not collaborate with them. Therefore, the transformation process is slow and difficult when the older structures are on the way or need to be dismantled first.

Lastly, implementing and utilizing digital technologies require a good amount of high quality data. Couple of the interviewees mentioned that companies lack a sufficient data that could be used with, for instance, artificial intelligence. In addition, the data can be stored in various places across the organization or in physical forms, which makes it harder to access it via digital methods. The theory highlighted the importance of having enough high-quality

data available in order for the technologies to function properly. Especially machine learning functions better the more data it has to process.

How can companies manage digitalization?

There are countless of ways to manage the digitalization and to save space, only the major approaches are mentioned here. The aspect of top management is stressed in this thesis since most of the strategies and changes require their initiatives. Therefore, in order to manage digital technologies, the executives should encourage their employees to start using the new solutions. Furthermore, there are always people who will resist changes and one solution for this is to just bypass their opinions and focus on driving the change. The interviewed companies clearly had a strong top management since they all stressed their commitment on developing new technologies. The results speak for themselves: many of the companies had made fairly quick changes in their approaches and organization structures.

Identifying the company's needs and places where value is created and destroyed is crucial for a successful management. Companies should not just buy new technologies if they have no real need for them. All the interviewees also mentioned the importance of first needing to understand the business and its targets for development before even considering investing in new technologies. The "proof of concept" was a popular term among the interviewees, even though, there was no mention about it in the theory section. It is an easy way to first test the technologies in smaller scales, especially when considering the fact that there are various providers to choose from, which complicates the finding of a suitable solution. Thus, it lowers the risk of implementing a wrong or useless solution in a larger scale.

The startup-like environment is seen as a solution for managing digitalization. This means that companies hire employees from different fields and industries to evoke a general innovation culture. These startup-programs usually include creating new smaller departments and giving them financing for their research and development. Other approach is to just hire new employees straight to the SCM positions with different backgrounds because this combines a comprehensive expertise and a set of habits within the same organization. The paper and packaging company was the most advanced interviewed company from this aspect since they have a semi-independent startup-program that creates

solutions for all departments in the company. The aviation company also emphasized their development in hiring new employees with various backgrounds.

6 Conclusion

In brief, the objectives of this thesis were to determine what the digitalization of supply chains look like today, what kind of digital technologies could be used in SCM, and how real-life companies are seeing this trend and using the technologies. The theory supported the empirical findings well since the interviewees acknowledged almost all the possibilities of digital technologies, and the process of utilizing them is well in progress in most cases. However, the development processes are not yet even close to ready due to the technologies constantly improving and the needs of the companies changing. Moreover, implementing all these new methods and solutions require a good sense of change management and plenty of technological know-how. It can be said that theoretical literature reflects well with the current situation of real markets.

The major differences between the theory and empirical findings were the capabilities of the digital technologies. The theory part identified several utilization methods of all the technologies, but the case companies did not take advantage of their full potential. For example, IoT technology was mainly used in the format of RFID, but the theory suggested many more possibilities, such as security and inventory management. When it comes to the management of digitalization, most of the case companies were aware of the ways of managing the transformation and used the same methods as mentioned in the theory.

6.1 Recommendations

This thesis will help any company or reader looking for improving its supply chain management with the help of digital technologies. One can find information on the general level of digitalization among supply chains, how to manage digital transformation, benefits, challenges and future views of five major digital technologies, or compare their own business with five other large-scale companies from different industries. There are many different aspects discussed during this study, thus there are much information for almost any need and interest regarding digitalization. In other words, this thesis gives the reader a timely and comprehensive basic understanding of digitalization in SCM. The reader does not have to be a top executive of a Fortune 500 company, but rather anyone interested in this topic.

The results give everyone working among supply chains valuable information, which increases the intangible assets of the whole company.

On the basis of this study, companies should boldly invest more in digital solutions and enhance their capabilities of managing them because the benefits are significant and clear. The paper and packaging company was a great example of a company finding new technologies and determining whether they could be in assist to the company. Of course, this requires plenty of money, but many smaller companies can also test a few digital solutions in a smaller scale with much less costs. It would be recommendable for companies to put efforts in change management since digitalization will bring many changes in the ways of working, and therefore resisting employees will always occur. If desiring to make the employees utilize the technologies, the management should convince them of the benefits and advantages the technologies can offer to them. When it comes to the digital technologies discussed in this thesis, their capabilities are far broader than the interviewed companies are using them for. Therefore, companies could try using their current technologies in other formats than they currently are using to see if they would help in other ways. Especially Internet of Things is a great example whose possibilities reach far beyond the RFID tags.

6.2 Limitations and future research

The results of this study would have been probably slightly different if there had been more companies and industries interviewed for the empirical section. Now there were five companies, but there are much more industries out there that have their unique habits of using digital technologies. Although, interviewing more companies would have required much more resources, which is hard to accomplish when conducting a study by yourself. Moreover, this topic required plenty of efforts to write about since the technologies are rather complex and new. Also, the results could have been different if there would have been more interviewees from the case companies due to them not knowing everything regarding the digital technologies in their organization.

Other limitation was the lack of many other digital technologies. Now only five major technologies were chosen, but there are also some others, such as virtual reality, augmented reality and 5G that could enhance SCM in their own ways. All digital technologies discussed

in this thesis were quite new and that posed a problem: they have not yet been studied or used that much. Because of this novelty, actual use-cases were hard to find especially about blockchain and artificial intelligence. The last limitation is that this study only scratched the surface of the digital technologies. All of them have many sub-technologies or variations that offer different solutions, and this was the reason why they were discussed merely in a general level.

There are definitely a few future research topics from this topic. The first suggestion would be to conduct this study in the format of longitudinal research because the technologies develop constantly, and the general situation of digitalization progresses rapidly. The results could easily be way different after a few years. Other topic could be to study only one or two technologies in a much more detailed level and find a workable solution of implementing them in a real business. Also, research could be done regarding other digital technologies, e.g. 5G and virtual reality because they are sometimes considered being as the technologies of the future as well.

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