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Purchasing Complex Services – Possibilities and Chances through Industry 4.0

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Abstract

Industry 4.0 will impact several areas of the business world. One of these areas is the purchasing of network construction. Network construction is imperative for our everyday lives, as it enables the supply with energy and fresh water. Yet nearly no research has been conducted in the area of network construction. In order to examine whether the purchasers of network construction can be assisted with Industry 4.0 technologies this study has been conducted. Additionally, this qualitative research aims to assist with the implementation of Industry 4.0 technologies in purchasing by segmenting the purchasing process into operational, tactical, and strategic elements. An extensive literature research has been conducted, covering the purchasing process, previous industrial revolutions, Industry 4.0 and purchasing various services. Afterwards 14 interviews with experts regarding network construction have been conducted, asking them about their daily challenges, Industry 4.0, and master data. Their answers led to the creation of 4 themes. These themes are IT Optimization, Process Optimization, Supplier Management, and Change Management. The obtained results indicate that the purchasers of network construction generally wish for a simpler and more streamlined software, automized minor purchases, and an improved internal and external interconnection. Additionally, the results have shown that there is a need to closely manage suppliers and manage the upcoming changes. Industry 4.0 will likely assist with IT and Process Optimization by introducing new Industry 4.0 supported systems and tendering platforms. Strikingly Industry 4.0 can be expected to aggravate supplier management and change management, through introducing and implementing new technologies within purchasing. If the current trend continues small construction companies will be squeezed out of the market due to their limited IT capabilities and the implementation of new systems and technologies will be difficult due to limited change management.

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Index of abbreviations

CIPS - Chartered Institute of Procurement

CPS - Cyber-Physical Systems

ERP – Enterprise Resource Planning

IoT – Internet of Things

IT – Information Technology

MRP – Materials Requirement Planning

RFI – Request for Information

RFQ – Request for Quotation

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1. Industry 4.0 is likely to change complex service purchasing, despite its absence in Industry 4.0 and purchasing literature

In today's fast changing world one word one topic has received a lot of attention over the last couple of years. For the recent past Industry 4.0 has been the buzzword in business literature. Industry 4.0 is no unanimously agreed term, but rather one out of a cluster of several names describing the same topic. Whether it is called Industry 4.0, "Industrie du futur", "Made in China 2025", or "Industrial Internet" (Rojko, 2017, p. 78), "Smart Manufacturing" or "Digitalization" (Geissbauer, Weissbarth &Wetzstein, 2016, p. 4), Industry 4.0 was first coined as "Industrie 4.0" by the German government at the Hannover fair in 2011 (Rojko, 2017, p. 80). Since then, numerous scientific articles have been published across a wide variety of fields. As of summer 2020, more than 8900 documents regarding Industry 4.0 can be found on Scopus and more than 3 million on Google Scholar. The fourth industrial revolution will lead to several changes, among them shorter development periods, a greater degree of individualization of products, decentralization flexibility and an increase in resource efficiency (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014, p. 239). Furthermore, new types of technology will be introduced into the business context, among them autonomous decision making by machines, as well as more computerized assists for labor tasks (Lasi et al, 2014, p. 240). The basis of Industry 4.0 will be data and data has therefore been called the "Gold of the digital age" (Baumhaus, 2016). Strikingly, the fourth industrial revolution will be the first industrial revolution to announce itself prior to its occurrence (Drath & Horch, 2014, p. 56). Industry 4.0 will transform supply chains and productions as we know them through several disruptive technologies (Lehmacher, Betti, Beecher, Grotemeier, & Lorenzen, 2017, p. 3). Yet these changes will build on existing technology and the development will be continuous (Wee, Kelly, Cattel & Breunig, 2015, p. 14; Schiele, 2016, p. 18). Nonetheless, Industry 4.0 could change todays supply chains and create new types of collaboration across company interfaces (Glas & Kleemann, 2016, p. 63). Because of Industry 4.0 procurement will have to rethink how it creates and adds value (Geissbauer, Weissbarth &Wetzstein, 2016, p. 5). Currently, most companies in central Europe give two thirds of their turnover directly to their suppliers (Schiele, 2016, p. 16).

While purchasing in combination with Industry 4.0 has not have been as closely examined as other strings of business literature, one type of purchasing is overlooked entirely, namely the purchasing of network construction. Network construction purchasing is a type of (complex) service purchasing and involves the construction of water pipes or power lines (see Figure 9).

What distinguishes network construction projects from regular construction is that network construction is difficult to standardize, as each project is entirely unique and dependent on several factors, i.e. soil conditions. Rarely any research has been conducted in context with network construction, despite of its importance to our everyday lives. This is especially concerning, as energy is the critical driver of human life as well as development (Asif & Muneer, 2007, p. 1389). Energy supply and energy security will be core topics of the coming years, as sustainable sources of energy become more and more dominant. Moreover, in Germany, energy companies are required by law to ensure a cost effective, sustainable, and secure energy supply (Federal Ministry for Economic Affairs and Energy, n.d.). This secure energy supply includes well build power lines and water pipes. Therefore, it is imperative to gain an understanding of the challenges and needs of purchasers of network and conduit construction, especially with Industry 4.0 and the changes it entails.

Services in general are purchased by a variety of different businesses, ranging from manufacturing companies to service providers themselves and public entities. Moreover, services are highly diverse, ranging from the most basic cleaning tasks to consultancy, engineering services or construction projects. It is important to differentiate purchasing goods from purchasing services, as they are highly different from each other in many ways (Van Weele, 2018, p. 82; see Table 2). Despite the importance and complexity of purchasing of (complex) services, the opportunities and challenges Industry 4.0 will cause in context with it have not been researched.

At the heart of each purchased service or item lies the purchasing process. Schiele (2016, p. 18) points out that Industry 4.0 will touch or change several aspects of the purchasing process, especially the negotiation. A pilot study by Pellengahr, Schulte, Richard, and Berg (2016), as well as my own previous research (Schiereck, 2018), have shown that purchasers expect that operational aspects of purchasing will be entirely digitalized, to a large extent even autonomously. Additionally, Carter P. L., Carter, J. R., Monczka, Slaight, and Swan (2000, p. 17) predicted at the beginning of the current millennia that some elements of purchasing would not be conducted by humans anymore, due to increased usage of technology.

In the current literature many different purchasing process models and definitions exist (see Bäckstrand, Suurmond, van Raaij, & Chen, 2019). The purchasing process itself has rarely been segmented and if it has, it has not been a prominent feature of any given model. Kaufmann (2002, p. 12) explains that his definition of “supply management” includes operational and strategic activities. Schifferer (2004, pp. 4-5) also segments the purchasing process into operational and strategic tasks but does not mention any tactical aspects. Schiele (2019, pp. 47-48) distinguishes between “Strategic Sourcing” and “Operative Procurement” when dissecting the purchasing process. Van Raaij (2016, p. 14) sections the purchasing process into operational, tactical, and strategic, but offers no exact definition and explanation for his sections. Rozemeijer (2008, p. 205) also segments into operational, tactical, and strategic, but refers to purchasing activities, not to the purchasing process. Van Weele (2018, p. 30) differentiates between the operational purchasing function and the tactical purchasing function. Yet, Van Weele (2018, p. 30) does not discuss any elements of the strategic purchasing function. Ramsey and Croom (2008, p. 193) partly offer an overview of literature, available at the time, focused on purchasing activities, but lay their main focus on purchasing as a whole, specifically on whether purchasing is seen as a strategic function intra-organizationally and what purchasing activities are strategic or not. Up to this point no clear differentiation of the purchasing process separate steps has been conducted to this point. Furthermore, no clear definition for operational, tactical, and strategic has been developed up to this point with the purchasing process in mind. Overall research has not developed a precise wording when it comes to segmenting the purchasing process and its adjacent concepts.

The aim of this research is to highlight the challenges purchasers of network construction or persons responsible for such purchases face and how Industry 4.0 technology can help them with their tasks. Additionally, this research aims to clarify purchasing terminology and the segmentation of the purchasing process, because without a clear basis it will be difficult to introduce Industry 4.0 elements in the purchasing process for i.e. complex services such as network construction. In order to achieve this, operational, tactical, and strategic purchasing are defined, and the purchasing process is segmented into operational, tactical, and strategic elements to enable purchasers to know exactly what task belongs into which category. Additionally, this research will aim to investigate whether the segmentation of the purchasing process and its associated tasks is considered viable and useful from a practitioner’s point of view. Likewise, the existing master data quality will be examined, as it represents the basis of any implementation of Industry 4.0. Furthermore, the purchasing of services, construction projects and network construction projects will be highlighted and described. Due to the lack of literature on the purchasing of network construction projects, literature focusing on complex services or complex construction projects will be used. Moreover, Industry 4.0’s key concepts and technologies will be defined and outlined. Additionally, Industry 4.0 will be historically classified to showcase what impact the previous industrial revolutions had and what impact the fourth industrial revolution will have.

The aim of this research led to the following research question:

How can purchasers of network construction (complex services) be assisted with the help of Industry 4.0 solutions, classified into different levels of purchasing?

And the following sub questions:

What are the problems purchasers of network construction are currently facing?

Is the segmented purchasing process viable for purchasing practitioners?

This thesis aims to aid with the challenges purchasers of network construction face and what chances and opportunities the fourth industrial revolution will bring about for them by offering guidance, whether Industry 4.0 technologies will help with the challenges they face. Moreover, it will give an overview, where internal procurement interfaces lie and where the latest technology can best be applied. Currently Industry 4.0 literature mainly focuses on the positive aspects of Industry 4.0 in manufacturing (e.g. Lehmacher, Betti, Beecher, Grotemeier, & Lorenzen, 2017; Glas & Kleemann, 2016). This thesis will support future studies by showcasing where new procurement solutions can be developed, old procurement solutions can be replaced, and knowledge gaps can be closed. Additionally, this thesis will aid purchasing related theory by providing a starting point for future research that is centered around the purchasing process, the purchasing of complex services and Industry 4.0 in general. Existing service purchasing literature primarily centers around business services and seems to neglect more complex ones (e.g. van der Valk & Rozemeijer, 2009; Van Weele, 2018). Furthermore, this study will deepen the knowledge of practitioners and theorists alike and will also provide a level playing field when discussing the purchasing process, as opinions and views of theory and practice usually tend to differ to a certain degree and leave a gap between the two sides (van de Ven, & Johnson, 2006, p. 802).

The thesis is structured as follows: it starts with a theoretical framework, during which basic purchasing terms are defined, Industry 4.0's historical position, concepts and technology are described and defined. Afterwards the purchasing process is accentuated and defined, operational purchasing, tactical purchasing and strategic purchasing are described and defined. Then the purchasing process is segmented into operational, tactical, and strategic elements. Afterwards, Industry 4.0 technologies are placed at fitting positions in the segmented purchasing process. Subsequently, service purchasing, construction project purchasing, and complex service purchasing are examined, and their unique attributes are highlighted and described. After the theoretical framework, the applied research methods are depicted. Next the collected data is presented. The following discussion section interprets the obtained results and its implications. Finally, a conclusion is drawn, and limitations and aspects for future research are highlighted.

2. Theoretical Framework: Procurement and the purchasing will be change by Industry 4.0's technologies and concepts

Due to the lack of purchasing related literature on operative, tactical, and strategic purchasing, literature from different fields will also be used to differentiate operative, tactical, and strategic purchasing. At first the procurement terms will be defined, followed by a detailed study of Industry 4.0 and its related concepts and implications, the purchasing process in general will be defined and explained, afterwards operative, tactical, and strategic as a noun will be generally defined. Next the three terms are defined using business and purchasing literature followed by listing corresponding purchasing activities. Lastly the purchasing process elements will be labelled as being either operational, tactical, or strategic.

2.1. Procurement and Purchasing are not the same

Throughout the entire procurement focused literature and practice, procurement, purchasing, and supply management are used interchangeably or defined differently. For example, some scholars, such as Kaufmann (2002, p.9), Cousins et al. (2008, p.7), or Dubois and Wynstra (2005, p. 4) argue that "procurement" and "purchasing" can be used interchangeably, others, such as Lysons and Farrington (2016, p.8), Bailey et al, (2015, p. 46) or Hong and Kwon (2012, p. 453) argue the opposite and use them as separate terms. To add another level of confusion, some parts of literature argue that "purchasing" is the overarching concept for the entire function (Schiele, 2019, p. 48; Monczka, Handfield, Giunipero, & Patterson, 2015, p. 11; Weigel & Ruecker, 2017, p. 2), whereas other parts argue that procurement is the overarching concept (Dobler & Burt, 1996, pp. 35-36; Van Weele & Eßig, 2017, p. 20; Lysons & Farrington, 2016, p. 8; Hong and Kwon, 2012, p. 453; Bailey et al, 2015, p. 46). Furthermore, to add to this confusion, if one compares English procurement literature with German procurement literature, one finds similar problems with the terms "Einkauf" (Purchasing) and "Beschaffung" (Procurement) being used interchangeably or are seen as one being part of the other (Van Weele & Eßig, 2017, p. 20-23). Moreover, throughout the years the definition for purchasing have transformed and have been applied differently in North America and Europe (Schiele, 2019, p. 47).

All in all, procurement focused literature lacks a clear understanding of basic procurement terms, which can lead to confusion when dealing with several different sources. In this thesis procurement and purchasing are not used interchangeably. Therefore, to highlight and clarify which definitions were used during the writing process of this thesis a few selected terms are previously defined to prevent misunderstanding:

2.1.1. Purchasing is defined as all tasks concerned with obtaining goods and services

The Chartered Institute of Procurement and Supply (CIPS) (CIPS a, n.d.) defines purchasing as “the processes concerned with acquiring goods and services, including payment of invoices – it is part of the wider procurement process”. Van Weele (2018, pp. 389-390) construes purchasing as “the management of the company’s resources in such a way that the supply of all goods, services, capabilities, and knowledge which are necessary for running, maintaining and managing the company’s primary and support activities is secured under the most favorable conditions”. Van Weele and Eßig (2017, p. 20) highlight that the term “purchasing” only encompasses the operational part of the order process. Purchasing is a part of the Procurement function (Lysons & Farrington, 2016, p. 8; see Figure 2). Murray (2009, p. 93) also points out that the purchasing cycle is a part of procurement and that purchasing does not concern itself with the “make-or-buy” question. For this thesis purchasing will be defined as all tasks concerned with obtaining goods and services.

2.1.2. Procurement is defined as comprising of all tasks and actions, including Purchasing, necessary to guarantee a steady flow of materials needed for the operation of the company

Procurement comprises of all activities necessary in managing external resources (Van Weele & Eßig, 2017, p. 20). Van Weele (2018, p. 389) defines procurement as including “all activities required in order to get the product from the supplier to its final destination”. Moreover, Van Weele (2018, p.389) points out that it contains the purchasing function. Sanderson, Lonsdale, Mannion and Matharu (2015, p. 22) define procurement as “(…) the process encompassing all activities associated with acquiring and managing the organisation’s supply inputs.” Lysons and Farrington (2016, p. 5) argue that “Procurement is a pro-active, strategic corporate activity to ensure a continuing supply of goods and services to enable world-class organisational performance.” Procurement concerns itself with several activities, one of them being purchasing (Lysons & Farrington, 2016, p.8). A further distinguishing factor is that procurement involves the make-or-buy question, which is typically undertaken at the senior management level (Murray, 2009, p. 93). For this thesis, procurement will be defined as comprising of all tasks and actions, including purchasing, necessary to guarantee a steady flow of materials needed for the operation of the company. Yet the main focus of this thesis will be centered around purchasing and its associated tasks.

2.2. By highlighting previous industrial revolutions, the future impact of the fourth industrial revolution on business and society becomes clear

This section covers Industry 4.0, its historical classification by showcasing the previous industrial revolutions, its origin and its concepts and technology. In order to be prepared for future developments one can focus on the past to learn from previous mistakes and shortcomings (Lipshitz, Ron & Popper, 2004, p. 98). Additionally, as modern globalized supply chains are susceptible to disruptions from various sources, it is a common practice to study previous events to prepare for future problems and developments (Pickett, 2003, p. 9; Pettit, Fiksel & Croxton, 2010, p. 13). To better understand the potential impact of Industry 4.0 on the economy and business life in general the previous industrial revolutions will be discussed, and their impact highlighted. Afterwards the Origin and history of Industry 4.0 will be described.

2.2.1. Substituting human power with machines defined the first industrial revolution

Landes (1969, p. 1) defines "industrial revolution" as a "complex of technological innovations which, substituting machines for human skill and inanimate power for human and animal force, brings about a shift from handicraft to manufacture and, so doing, gives birth to a modern economy." Generally, industrial revolution is defined as:" a period in which the development of machinery leads to major changes in agriculture, industry, transportation, and social conditions" (Cambridge Dictionary, n.d.). The term, "industrial revolution" in general describes rapid technological advancements (Landes, 1969, p.1). Commonly, the developments that took place in the late 18th to early 19th century in Great Britain are known as the industrial revolution or first industrial revolution (Schiele, 2016, p. 15; Berg & Hudson, 1992, p. 2; Rojko, 2017, p. 78). Three key developments can be attributed for the rapid advancements during that time period, namely: replacing human abilities with machine tools, substituting human and animal power with power from machines (steam engines) and easier access to and processing of natural resources, specifically in chemical and metal related fields (Landes, 1969, p. 1; see Figure 2). One notable invention that heavily influenced the time period as a whole was the steam engine (Kras, 2004, p. 16; Roser, 2015; see Figure 2). The first commercially sold and functioning steam engine was patented by the English inventor Thomas Savery in 1698 (Kras, 2004, p. 21). Savery developed a machine that used steam power to pump water, however it was rather complicated and unpractical (Kras, 2004, pp. 21-22). A more practical and easier to use steam machine was developed by Thomas Newcomen in 1712 and improved several of the drawbacks of the steam machine by Thomas Savery (Kras, 2004, p. 25; Frenken & Nuvolari, 2004, p. 421). Both steam engines by Thomas Savery and Thomas Newcomen could only be used to pump water (Kras, 2004, p. 26). Scottish inventor James Watt improved the engine by Thomas Newcomen to be more economical, through his version being more fuel efficient (Kras, 2004, p. 28; Frenken & Nuvolari, 2004, p. 421). Watts patented his new improved steam engine in 1769 (Kras, 2004, p. 28; Frenken & Nuvolari, 2004, p. 421). Watts newly developed steam engine was commercially successful and used in different industrial fields, i.e. iron works (Kras, 2004, p. 31; Ayres, 1989, p. 13). The rise of the steam engine enabled a greater deal of centralization regarding the equipment and the workforce used to manufacture goods and therefore factories and mills were created (Kras, 2004, p. 55; Landes, 1969, p. 2). Because of the increased usage of steam engines in various aspects of industry and transportation, and the increased industrialization the standard of living consecutively increased and it altered the environment in the United States of America, Great Britain, and continental Europe. (Schiele, 2016, p. 15; Kras, 2004, p. 74).

2.2.2. Mass production and division of labor characterized the second industrial revolution

Between roughly 1870 and 1914 the so called second industrial revolution occurred in several industrialized nations, among them Great Britain, France, United States of America, and Germany (Mokyr, 1999, p. 1). The second industrial revolution was characterized by the introduction of mass production and the division of labor, which meant simplifying work tasks, so that each worker would only complete a minor part of a product (Barthelmäs et al., 2017, p. 39; see Figure 2). During this period, the steam engine was replaced with the electric motor (Schiele, 2016, p. 15, Lasi et al, 2014, p. 239). The second industrial revolution also saw the emergence of large corporations, due to high economies of scale and an increase in throughput (Mokyr, 1999, p. 2). In general, the second industrial revolution was characterized by advancements in the field of production and electricity (Roser, 2015; Rojko, 2017, p. 78; see Figure 2). Other areas where groundbreaking developments were made include: steel, chemicals, electricity, transportation, production engineering, and agriculture and food processing (Mokyr, 1999, pp. 2-9). The ability to produce steel cheaply, was made possible in 1856 by Henry Bessemer (Mokyr, 1999, p. 2). Due to the lower price, steel was used in many more areas than before, i.e. buildings, ships, and railroad tracks (Mokyr, 1999, p. 3). In chemistry, a notable event was the discovery of artificial dye by William Perkin in 1856 (Mokyr, 1999, p. 3). Another important event in chemistry was the invention of the vulcanization process by American inventor Charles Goodyear in 1839, which enabled the large-scale usage of rubber in various fields (Mokyr, 1999, p. 4). Additionally, the importance of the creation of synthetic plastic in 1869 by the American John Wesley Hyatt cannot be overstated (Mokyr, 1999, p. 4). The field of electricity saw the invention of the self-excited generator by C.F. Varley and Werner von Siemens in 1870 and the invention of the modern lightbulb by the English inventor Joseph Swan and the American inventor Thomas A. Edison (Mokyr, 1999, p. 5). The first real electric engine was developed by the Prussian inventor Moritz Hermann Jacobi in 1834 (Doppelbauer, 2013, p. 8). Of equal importance was the development of the electric poly-phase motor by American inventor Nikola Tesla in 1889 (Mokyr, 1999, p. 6). All in all, electricity was more widely used in the 1870s, for example with electric passenger cars being in operation in Frankfurt and Glasgow (Mokyr, 1999, p. 6). In the area of transportation, notable developments were invention of the four-stroke gas engine by German inventor Nicolaus August Otto in 1876, the diesel engine by Rudolf Diesel in 1897 and the usage of electric locomotives (Mokyr, 1999, p. 6). Although other inventors build similar vehicles, the invention of the car is credited to German inventor Carl Friedrich Benz, who patented the first automobile using a four-stroke engine in 1886 (Kirchberg, Wächtler, & Goetz, 1981, p. 32; Mokyr, 1999, p. 7). Moreover, shipping also saw striking developments, since due to the availability of cheap steel, larger ships and vessels were build (Mokyr, 1999, p. 6). In production engineering the major breakthroughs were the introduction of interchangeable parts, the assembly line, and the combination of the two (Mokyr, 1999, p. 8). The assembly line was developed by Henry Ford 1913, who took inspiration from the meat industry (Kranzberg & Hannan, 2017). The combination of interchangeable parts and the assembly line process revolutionized manufacturing and enabled Ford to keep the costs low and yet mass produce a sophisticated product (Mokyr, 1999, p. 8). Regarding agriculture, the major breakthroughs concerned the increased usage of artificial fertilizers and fungicides, apart from that new products were developed, such as drainage pipes or steam-operated threshers, but overall agriculture was still highly dependent on manual labor (Mokyr, 1999, p. 9).

2.2.3. Digitalization and automation characterized the third industrial revolution

The third industrial revolution, also known as the digital revolution, started in the 1970s and it marked the starting point of the information age (Greenwood, 1999, p. 2; Hornstein, 1999, pp. 1-2; Debjani, 2014, p. 107; Lasi et al, 2014, p. 239; see Figure 2). Greenwood (1999, p. 2) defines the third industrial revolution as “an era of rapid technological progress associated with the development of information technologies”. One major aspect of the third industrial revolution is the increased usage of machines for former manual tasks and also minor “intellectual” tasks (Kagermann, Helbig, Hellinger, & Wahlster, 2013, p. 14; Roser, 2015; see Figure 2). Moreover, the third industrial revolution is characterized by a shift from mechanical and analogue technology to digital technology (Debjani, 2014, p. 107). Notable drivers of the third industrial revolution were circuit boards and microprocessors and it involved automation and digitalization (Schiele, 2016, p. 15; see Figure 2). Most importantly the new ability to mass produce digital logic circuits enabled the development of i.e. mobile phones, fax machines and computers (Benjani, 2014, p. 107). The importance of the introduction of the personal computer in the 1980s cannot be overstated (Greenwood, 1999, p. 10). Prior to the widespread availability and usage of personal computers, specialized computers were only found in scientific laboratories, weather forecasting stations or educational facilities, such as universities to process large amounts of data (Khan, 1987, p. 115). Another important indicator that is showcasing the technological advancements is the sharp decrease in prices for computers and computer related parts in the 1970s (Greenwood, 1999, pp. 2-3). Additionally, each new generation of computers and computer related parts is able to perform faster than the previous generation for the same or a comparable price (Hornstein, 1999, p. 2). As a result of the increased usage of computers and increasing performance, new products and services could be introduced, and production process were completely reshaped (Hornstein, 1999, p. 2). Repetitive tasks in office environments that involved calculations could be automated through using computers and therefore saved time and labor (Khan, 1987, pp. 115-116). These developments enabled financial savings for companies as the cost of implementing computers was offset by cheap hardware prices and reduced labor costs (Khan, 1987, pp. 115-116). Advancements in telecommunications also played a large role during the third industrial revolution (Khan, 1987, p. 116). One aspect of these advancements was the significant increase in the speed of message transmission through thin optical-fiber cables, which increased from being transmitted at the speed of sound to being transmitted at the speed of light (Khan ,1987, p. 116). Another field with substantial progress concerned automation and robotics (Khan, 1987, p. 118). Leading in this field were auto manufacturers, such as General Motors, Volkswagen, and Nissan, because they employed a great number of robots in their manufacturing plants (Khan, 1987, p. 118). These aforementioned robots were used to weld, paint, assemble, store, and transport, with Volkswagen having been one of the manufacturers to make the most use of such possibilities (Khan, 1987, p. 119). The usage of new robot technology also enabled car manufacture to produce flexibly, meaning that different models of cars can be produced at the same time without the need for retooling, which was not possible before (Khan, 1987, p. 119). Additionally, through these advancements it was possible to increase production without hiring of extra personnel (Schiele, 2016, p. 15). All of these developments in telecommunication, robotics and micro technologies enabled a greater deal of globalization in various aspects, ranging from research to production (Khan, 1987, pp. 119-120).

2.2.4. The term Industry 4.0 was created by a German government initiative

The fourth industrial revolution or Industry 4.0 has its origin in Germany (Lasi et al, 2014, p. 240; Smit, Kreutzer, Möller, & Carlberg, 2016, p. 20), where the term was coined at the Hannover fair in 2011 (Rojko, 2017, p. 80). Afterwards the term was first widely used by the German government advisory council "Forschungsunion" in their report "Wohlstand durch Forschung – Vor welchen Aufgaben steht Deutschland?", which was published in 2013 (Barner et al., 2013). The report concerned itself with research and innovation policies in the areas of "climate, energy, health, food, sustainable mobility, communication, information technology and security" (Barner et al., 2013, pp. 6-7). Moreover, goals that were set in the report had a long-term focus that extended over traditional legislative periods and concerned themselves with areas such as digitalization, demographic change, or research (Barner et al., 2013, p. 7). It is important to note that Industry 4.0 is a long-term strategy, rather than being focused on short-term goals (Smit et al., 2016, p. 20) What is striking about Industry 4.0 or the fourth industrial revolution is that it will be the first industrial revolution that will announce itself prior to its occurrence (Drath & Horch, 2014, p. 56), and is not named and framed after it occurred. Other countries have not necessarily adopted the same terminology but deal with similar challenges under different names. Notable government initiatives and projects from other countries include: China's "Made in China 2025" initiative, which was heavily influenced and inspired by Germany's Industry 4.0 and aims to improve the Chinese industry and adapt Industry 4.0 to China's needs; France's "Industrie du future" industrial policy, which focuses on connecting industry and science, researching and using new technologies, helping French companies with new technologies, educate employees on new technologies, increase multi-national standards and cooperation, and promoting future focused French industries (Rojko, 2017, p. 78).

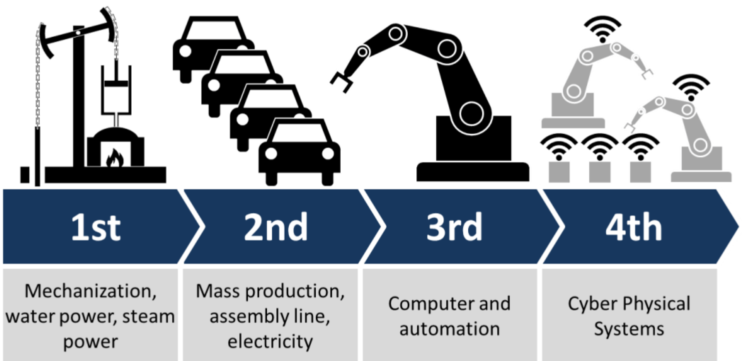

Figure 1: Illustration for Industry 4.0 and Industrial Revolutions leading up to it by Roser, C. (2015)

2.3. Industry 4.0 consists of several technologies, with Big Data, CPS and machine-to-machine communication being the most dominant ones

Characteristically, all previous industrial revolutions brought with them some form of technological advancement, but the most striking development, that caused the biggest changes, were those that caused a change in production organization or production chain (Schiele, 2016, p. 16). The fourth industrial revolution is projected to be highly influenced by machine-to-machine communication and cyber-physical systems (see Figure 2; Roser, 2015; Schiele, 2016, pp. 15-16; Rojko, 2017, p. 77; Drath & Horch, 2014, p. 56; Hermann, Pentek & Otto, 2016, p. 3928; Torn, & Schiele, 2020, pp. 511-512). Industry 4.0 is expected to drastically change manufacturing and production by introducing new technologies that allow for a faster and tailored response to customer demand (Rojko, 2017, p. 77). Generally speaking, Industry 4.0 will require several changes in business and its environment: development cycles will have to be shortened, products will have to be more tailored for the individual customer, more flexibility regarding production and development will be necessary, internal hierarchies will have to be revised, and the available resources have to be used more efficiently due to scarcity and because of societal pressure. (Lasi et al, 2014, p. 239). Additionally, innovative products like 3D printers, that are already present in private life will make their way industrial scenarios (Lasi et al, 2014, p. 240). When concerning oneself with Industry 4.0 as a topic in general, several further technical terms and technologies are frequently used in connection with Industry 4.0 (see Figure 2). Among them are the following terms, “Artificial Intelligence”, “Cyber-Physical Systems” (CPS), “Machine-to-Machine Communication”, “(Industrial) Internet of Things” (IoT), “Big Data”, “Cloud Computing”, and “Smart Manufacturing” (Wang & Wang, 2016, p. 2; Bechtold, Lauenstein, Kern & Bernhofer, 2014, p. 4; Schiele, 2016, p. 16; Rojko, 2017, p. 77; Smit, et al., 2016, p. 22). In the following part each technology or concept will defined and described, as well as possible implications.

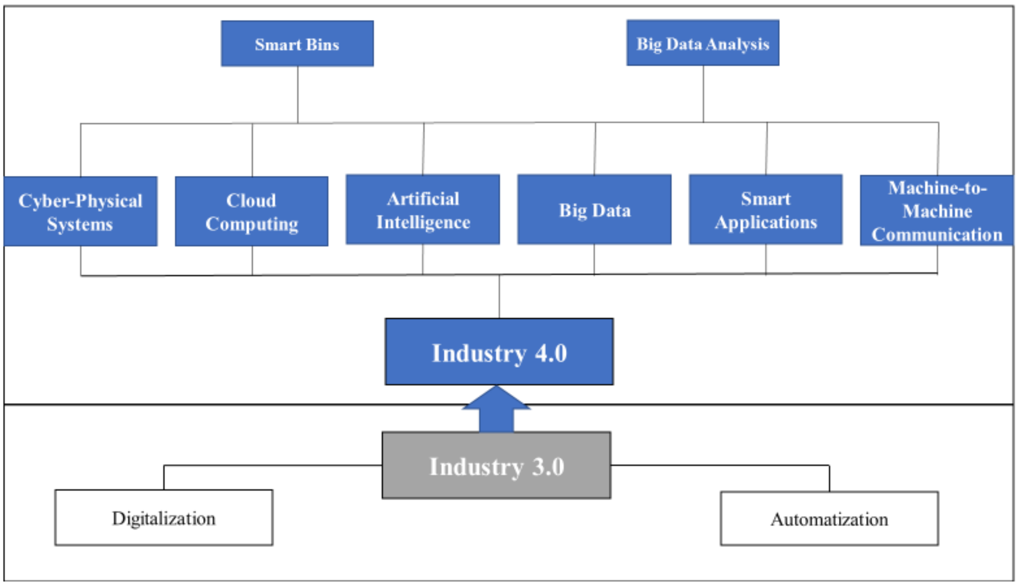

Figure 2: Simplified Overview of Industry 4.0 with exemplary Technologies

2.3.1. Data is the basis for any implementation of Industry 4.0 in practice

Basic data is the basis for all IT solutions to be able to generate the desired results ranging from documents to information (Nienke & Birkmeier, 2015, p. 52). Moreover, the importance of data is growing with the progressing implementation of Industry 4.0 (Raptis et al., 2019, p. 97054). Furthermore, companies focus more and more on master data quality (Otto et al., 2011, p. 396). Generally, data is defined as "information, especially facts or numbers, collected to be examined and considered and used to help decision-making, or information in an electronic form that can be stored and used by a computer" ("Data," n.d.). Data is considered as an essential element of the economy and as vital to companies (Mosley et al., 2009, p. 1). One form of data is master data. Master data is "data about the business entities that provide context for business transactions" (Mosley et al., 2009, p. 176). Typically, master data of companies contains data about e.g. customers, goods, or suppliers (Mosley et al., 2009, p. 176). Haug & Stentoft Arlbjørn (2011, p. 289) claim that many companies face problems related to bad master data, which stems from technological developments. Bad (master) data quality cause delays in internal and external process through forcing employees to recheck and double check data (Nienke & Birkmeier, 2015, p. 52). If too much faulty or bad data piles up it can force a company's operations to a standstill (Nienke & Birkmeier, 2015, p. 52). Even a minor number of faulty master data can negatively impact a company's revenue (Haug & Stentoft Arlbjørn, 2011, p. 289). Examples of faulty master data are wrong addresses, wrong prices, or wrong account numbers (Haug & Stentoft Arlbjørn, 2011, p. 289). Beneficial to a good level of master data quality is a high degree of centralization and formalization (Nienke & Birkmeier, 2015, p.

54). Master data management facilitates a company’s operations by providing clear and consistent master data sets (Fleckenstein & Fellows, 2018, pp. 94-95). Moreover, master data is one of the enablers of implementing Industry 4.0 solutions (Raptis et al., 2019, p. 97054). All in all, good quality (master) data is the basis for an implementation and usage of Industry 4.0 technologies.

2.3.2. Artificial Intelligence is one of the enablers of Industry 4.0 solutions and uses data provided by Industry 4.0 technologies

Although not stemming from Industry 4.0, Artificial Intelligence is an indispensable part of Industry 4.0 (Siemens, n.d., para. 3). Torn and Schiele (2020, p. 513) list Artificial intelligence as one of the key technologies of Industry 4.0 and its application in purchasing. Generally, Artificial Intelligence is considered as one of the base and key technology for Industry 4.0 (Salkin et al., 2017, p. 5; Sarvari et al., 2017, p. 97; Tjahjono et al., 2017, p. 1176). Artificial Intelligence concerns itself with how computers can perform tasks in the same way humans do (Lackes & Siepermann, 2018). Altogether, Artificial Intelligence is able to make decisions on the basis of data, that has been inserted or with which the Artificial Intelligence has been “trained” (Federal Ministry for Economic Affairs and Energy (BMWi, 2019, p. 5). Furthermore, Artificial Intelligence should be capable to understand and examine new ideas, learn from previous actions, reason, conclude, interpret various patterns or images, and attribute significance (Min, 2010, p. 14). It is important to note that although Artificial Intelligence is able to make own decisions and perform functions, its limits and areas of operations are defined by humans (BMWi, 2019, p. 20). Additionally, Artificial Intelligence currently is only able to create new elements or concepts within the confines of its programming (Hermann et al., 2017, p. p. 245). All in all, Artificial Intelligence is one of the enabling technologies of Industry 4.0, by linking the different technologies and being able to make decisions and conduct actions on the basis of the provided data (Lee et al., 2019, pp. 30-32).

2.3.3. Cyber Physical Systems link physical items with a digital twin

The first aspect of Industry 4.0 to be considered are “Cyber Physical Systems” (see Figure 2 and Figure 3). Cyber Physical Systems involve the following key aspects: tangible items and a system of connections, where the tangible items have an intangible virtual model and where the information is employed to perform a certain service (Drath & Horch, 2014, p. 57). Cyber Physical Systems do not introduce new technologies, but rather combine existing ones to create new usages and services with near endless possibilities (Drath & Horch, 2014, p. 57). Moreover, Cyber Physical Systems are expected to cover both production and the end product (Lasi et al, 2014, p. 240). Due to the greater availability and feasibility of several key elements of Cyber Physical Systems, such as sensors or data software, more companies are implementing new technological advancements (Lee, Bagheri, & Kao, 2014, p. 1). One striking benefit of Cyber-Physical Systems is that downtime of the production process can also be almost entirely avoided by using Cyber-Physical Systems at every step of production, as a large amount of data allows for self-maintenance and self-configuration of the manufacturing plant (Lee, Bagheri, & Kao, 2014, p. 22). Additionally, through using Cyber-Physical Systems throughout the entire production process, companies can accrue several advantages, like improved inventory management, advanced production planning or improved maintenance schedules (Lee, Bagheri, & Kao, 2014, p. 22). An example of such a system would be a machine autonomously checking inventory levels and deciding that it is time to restock without any human interaction (Schiele, 2016, p. 16). An already widely used example is a power grid, where wind farms or other types of renewable energies are the physical part and sensors transmit data to computers that maximize the usage of the energy sources (Khaitan & McCalley, 2015, p. 1). Another example is the recording of physical wear on machines and combining these with the digital outputs, such as productive time, to assess the real condition of machines (Lasi et al, 2014, p. 240).

2.3.4. Big Data enables new ways to analyze and use large amounts of data

Another element of Industry 4.0 is "Big Data" (see Figure 2). Big Data on its own describes a data set that cannot be analyzed with current data analysis software, because of its magnitude, extent, complexity, and design (Kang et al., 2016, p. 119). In order to be able to work a with such types of data and obtain information from these data sets, special programs and systems have to be used (Kang et al., 2016, p. 119). By analyzing Big Data, manufacturing efficiency will be improved by enhancing machinery service, decreasing power expenses, and enhancing manufacturing quality (Wang & Wang, 2016, p. 4). Moreover, Big Data and Big Data Analytics enable the implementation of Smart Manufacturing in production (Kang et al., 2016, p. 119). Additionally, the analysis of Big Data allows for the detection of previously hidden problems, such as wear and tear or degradation on machinery and equipment in manufacturing (Smit et al., 2016, p. 23). Moreover, companies who are data-driven (use big data), perform better than their competitors who are not (McAfee & Brynjolfsson, 2012, p. 6). Yet, Big Data also brings about a number of challenges and problems that need to be addressed and dealt with, among them are data volume, data speed, and data diversity (Buhl, Röglinger, Moser, & Heidemann, 2013, pp. 63-64). Also, as a result of the increased usage of mobile phone applications and social networks, more data source have become available and have to be managed (Buhl, Röglinger, Moser, & Heidemann, 2013, p. 64). Furthermore, due to the larger amount of data, waste data is likely to be a major issue (Buhl, Röglinger, Moser, & Heidemann, 2013, p. 64). The bulk of available data also has to be handled in such a way that the right information is accessible at the right moment and can be analyzed right away (Buhl, Röglinger, Moser, & Heidemann, 2013, p. 64). All in all, Big Data connects new data sources with existing software to enable new ways to analyze, store, and use data to enhance efficiency and problem solving.

2.3.5. Machine-to-Machine Communication is a key technology of Industry 4.0 and can be applied in both industrial and private settings

Machine-to-Machine Communication is one of the cornerstones of the Industry 4.0 environment, as close communication connecting over varying ranges is one of the key elements (Weyrich, Schmidt, & Ebert, 2014, p. 1; see Figure 2). It involves the communication of various machines and electronic devices and it is often linked with decision making of these machines and devices, in some cases autonomous decision making (Watson, Piette, Sezgen, Motegi, & ten Hope, 2004, p. 1). Autonomy, in an Industry 4.0 environment, constitutes the ability of a system or machine to make decisions on its own, without human interaction (Torn & Schiele, 2018, para. 15). Autonomy does not differentiate whether the machines is making the decision based on a pre-set algorithm or if artificial intelligence is making the decision (Torn & Schiele, 2020, p. 513). One of the key features of Machine-to-Machine Communication is the almost complete absence of human interaction during its usage, servicing, preparation, and stationing (Dohler et al., 2014, p. 1). Activities that machines are able to perform without human interaction and with machine-to-machine communication are "sensing, processing, and actuation activities (…) "(Amodu, & Othman, 2018, p. 255). Incremental elements of machine-to-machine communication are high security standards, cost effectiveness and durability (Weyrich, Schmidt, & Ebert, 2014, p. 1). Another essential element for machine-to-machine communication is the development of (open) industry standards that allow for greater adoption and advancement (Amodu, & Othman, 2018, p. 265). Also, it is imperative that the technological basis has to permit interoperability regarding servicing, structure, and norms (Amodu, & Othman, 2018, p. 271). Whereas wire-based machine-to-machine communication has been used before, wireless machine-to-machine communication is starting to be more widely adopted, especially in production environments (Weyrich, Schmidt, & Ebert, 2014, p. 1). Moreover, machine-to-machine communication is especially useful in logistics, as it allows for direct communication between different aspects of the logistic chain, i.e. forklifts, trucks, tracked material (Weyrich, Schmidt, & Ebert, 2014, p. 1). By allowing for close communication in the logistic chain, mistakes, and low inventory levels can be avoided (Weyrich, Schmidt, & Ebert, 2014, p. 1). Additionally, machine-to-machine communication can used in several other fields, including health, safety, household, and communal applications (Amodu, & Othman, 2018, p. 255). Dohler et al. (2014, p. 1) name several example applications for machine-to machine communication, among them are "telemetry readings of a vehicle fleet, occupancy measurements of parking in cities, or remote measuring of gas consumption". Finally, machine-to-machine communication will impact manufacturing and business life, as well as everyday life, due to its universal applicability and wide range of possible utilization.

2.3.6. The Internet of Things is a base technology for other Industry 4.0 solutions and enables smart products

The next aspect of Industry 4.0 is the Internet of Things. Internet of Things is a "smart environment concept" and can be defined as enabling objects, such as sensors or mobile phones to communicate with each other and work together with other smart products to fulfill certain needs (Giusto, Iera, Morabito, & Atzori, 2010, p. v). From a systemic perspective the IoT is a "highly dynamic and radically distributed network system", that consists of "smart objects producing and consuming information" (Miorandi et al., 2012, p. 1498). The IoT represents a base technology that is used as a basis for many Industry 4.0 technologies, i.e. CPSs or smart manufacturing (Kang et al., 2016, p.120). Additionally, the key element of the IoT will be the linking of products, machines and components by incorporating sensors (Wang & Wang, 2016, p. 2). Through using the IoT concept, factories and their production processes can be transformed into a smart environment (Kagermann, Helbig, Hellinger, & Wahlster, 2013, p. 14). Each physical object in the IoT will be identifiable by using a unique IP-address, which will be used to exchange information in a smart system (Anderl, 2014, pp. 4-5). Furthermore, each object equipped with an IP-address will be traceable, locatable, and identifiable (Anderl, 2014, p. 5). Currently, the IoT and sensors are more prevalent in private homes, than in manufacturing facilities, but they are becoming more and more present in manufacturing (Kang et al., 2016, p. 123). Other areas of application include "smart cities", i.e. traffic control, "environmental monitoring", i.e. warning people in case of natural catastrophes, "health-care", i.e. monitoring physical parameters like blood pressure, and "security", i.e. sensors replacing cameras in some security scenarios to ensure more privacy (Miorandi et al., 2012, pp. 1510-1511). Furthermore, the IoT will also bring about a number of challenges, including business model adaption, due to the location of the particular products in the IoT, shifts in company cultures, changes in customer care and after sales services due to connected products, or changes in marketing, i.e. using connected products (Wortmann & Flüchter, 2015, p. 224). A current example where the IoT is used is in the contact tracing of Corona cases through using smartphone applications (Singh, Javaid, Haleem, & Suman, 2020, p. 522).

2.3.7. Cloud Capabilities offer cost savings and on demand services through providing storage and computational power

A further element of Industry 4.0 is Cloud Computing. The term Cloud Computing stands for an assortment of services, programs and systems that are offered through internet and can be used without extensive IT-knowledge (Repschläger, Pannicke, & Zarnekow, 2010, p. 6). Cloud Computing provides computational power and digital storage in digitalized manufacturing or production contexts (Wang & Wang, 2016, p. 4). A good example for cloud computing is Google's docs service, where the majority of the work is carried out unseen to the user through systems that are potentially geographically scattered (Hayes, 2008, p. 9). The foundations of cloud computing are existing technologies and programs (Repschläger, Pannicke, & Zarnekow, 2010, p. 6). The benefits of cloud computing include that the customer only pays for the service itself, regardless of the usage and does not have to concern themselves with running of the systems or maintenance of the systems and similar issues (Repschläger, Pannicke, & Zarnekow, 2010, p. 6). Repschläger, Pannicke and Zarnekow (2010, pp. 7-8) distinguish between three different cloud computing types: "Private Cloud, Public Cloud and Hybrid Cloud". A Private Cloud is comparable to an intranet, where all programs and systems remain in a company owned datacenter (Repschläger, Pannicke, & Zarnekow, 2010, p. 8). Whereas, in a public cloud all data and applications are stored on the systems of the provider of the cloud (Repschläger, Pannicke, & Zarnekow, 2010, p. 8). In a hybrid cloud noncritical systems and data are stored with the provider of the cloud and all sensitive data and critical systems remain with the buyer (Repschläger, Pannicke, & Zarnekow, 2010, p. 8). Central issues to cloud computing that have to be dealt with are security, privacy, and reliability (Hayes, 2008, p. 11). The topics of security and privacy are not to be underestimated, since they are highly important to most users and customers, especially in IT scenarios (Meehan, 2019). All in all, users of cloud systems can reduce their costs by avoiding binding capital in expensive IT-systems and have the flexibility to react quickly to capacity changes (Repschläger, Pannicke, & Zarnekow, 2010, p. 8).

2.3.8. Smart Manufacturing allows to meet demand in real-time and uses many Industry 4.0 technologies

The next aspect of Industry 4.0 to be highlighted is Smart Manufacturing. Smart Manufacturing has its origin in the United States of America, where it was coined by governmental agencies (Thoben et al., 2017, p. 6; Mittal et al., 2017, p. 1344) There is no generally accepted definition of Smart Manufacturing (Kusiak, 2018, p. 509). One definition for Smart Manufacturing is, that it is a "fully-integrated, collaborative manufacturing [system] that respond[s] in real time to meet changing demands and conditions in the factory, in the supply network, and in customer needs" (National Institute of Standards and Technology (NIST), 2018). Another definition describes Smart Manufacturing as being a manufacturing system "(…) that can respond to complicated and diversified situation of manufacturing field in real-time" (Kang et al., 2016, p. 111). Kusiak (2018, p. 516) summarizes that smart manufacturing is essentially concerned with "autonomy, evolution, simulation and optimization" of manufacturing. Among the key technologies of smart manufacturing are IoT, CPS and cloud applications, which have been researched by the United States and Germany over the past few years (Kang et al., 2016, p. 111). Zheng et al. (2018, p. 137) stress that the application of CPS in manufacturing is at the center of what will make manufacturing "smart". Smart manufacturing will replace traditional blue-collar jobs with new types of ("cyber") white-collar jobs, but this replacing will cause further challenges on its own (Kusiak, 2018, p. 514). All things considered, smart manufacturing will enable increases in productivity and flexibility, as well the ability to cope with changing demands and other challenges.

2.4. The purchasing process design may vary depending on the author, but the essence remains

In order to apply Industry 4.0 in purchasing and to be able to have a detailed overview of all necessary tasks needed to purchase an item or service a detailed purchasing process is essential for successful procurement. Furthermore, the input needed for the purchasing process are clear company demands and specifications (Van Weele, 2018, p. 28). Several different models have been developed over the years to map these processes. The majority of them have a similar order and wording with only minor differences (i.e. Monczka et al. 2015, p. 52; Aissaoui, Haouari, & Hassini, 2007, pp. 3516-3517; van Weele & Eßig, 2017, p. 50; van Weele, 2018, p. 29; Bailey et al. 2011, p. 8; Schiele, 2019, p. 48). Bäckstrand, Suurmond, van Raij and Chen (2019, p. 4) found in their study, concerning purchasing process models, that the majority of the linear purchasing process models either use van Weeles base model or an adapted version of it. Therefore, the Linear Purchasing Process Approach by van Weele (2018, pp. 28-46) will be used as a base for this thesis. Furthermore, the purchasing process can be subdivided into operational, tactical, and strategic elements. This enables a further division of labor, responsibilities, and introduction of new technologies. Yet there is no clear segmentation of the purchasing process.

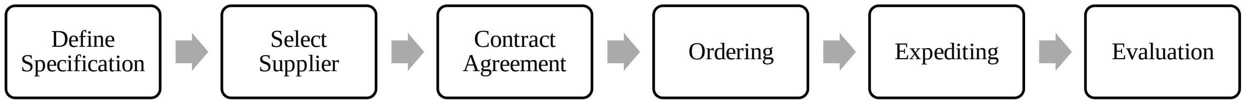

Figure 3: Linear Purchasing Process Approach adapted from Van Weele (2018, p. 28).

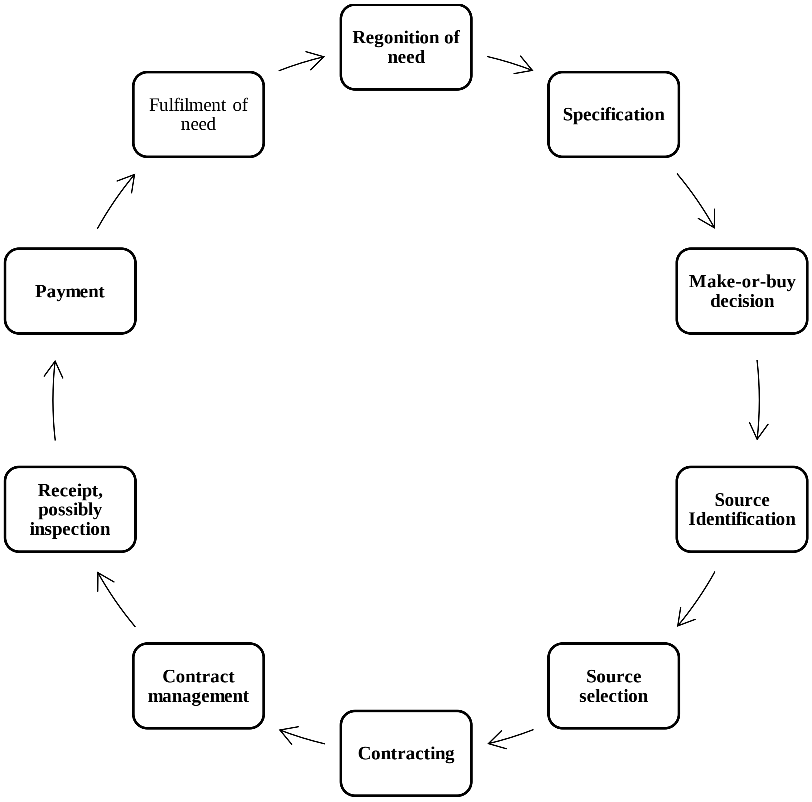

Figure 4: Purchasing Cycle, adapted from Bailey (2011, p.8).

2.4.1. Purchasing process as it is described in literature (Van Weele, 2018)

The most commonly referred to description and definition of the purchasing process is by Van Weele (2018, p. 28). Van Weele (2018, p. 28) divides the purchasing process into the following steps "Define Specification, Select Supplier, Contract Agreement, Ordering, Expediting, and Evaluation". In the following part each individual step is described and defined.

2.4.1.1. Specifying what is needed

The first step of the purchasing process by van Weele (2018, p. 28) is called "Define Specification". It involves "functional specification, technical changes and bringing supplier knowledge to engineering" (Van Weele, 2018, p.28). It is the primary step of the linear purchasing process during which the prerequisites are established and the "make-or-buy" decision is made (Van Weele, 2018, p. 36). If the company decides to buy the product or service, functional and technical specifications must be determined (Van Weele, 2018, p. 36). Functional specifications show what the buyer expects the product to do or what abilities the product should have (Van Weele, 2018, pp. 36-37). Technical Specifications describe the exact technical characteristics and features of the product, including what standards and norms the product should meet (Van Weele, 2018, p. 37) Highly detailed technical drawings and graphics are included in the technical specifications (Van Weele, 2018, p. 37). Both functional and technical specifications are part of the purchase order specification, which involves all relevant specifications (Van Weele, 2018, p. 37). The purchaser is expected to safeguard that the latest specifications are known to the supplier and that production or service is conducted in adherence to these specifications (Van Weele, 2018, p. 37). Furthermore, during the specification phase close communication and collaboration of the purchasing department with the requesting departments, i.e. the engineering department is essential (Johnsen, Howard, & Miemczyk, 2014, p. 37).

2.4.1.2. Selecting the most suitable supplier

The second step of the Linear Purchasing Process is called "Select Supplier" (Van Weele, 2018, p. 28). Van Weele (2018, p. 29) defines "Supplier Selection" as involving "all activities, which are required to select the best possible supplier". It includes the following activities deciding the method for subcontracting, initial assessment of suppliers, prepare the bidders list, arranging the request for quotation, examining the obtained offers, and choosing the supplier (Van Weele, 2018, p. 29). From a practical standpoint the first and second step are often interlaced (Van Weele, 2018, p. 37).

Van Weele (2018, p. 38) lists 4 steps that make up the "Select Supplier" phase. Starting off with the issue of "determining the method of subcontracting", which involves whether the particular product is delivered by a single supplier or elements are outsourced (Van Weele, 2018, p. 38). While offering financial savings, partial outsourcing requires all contracts to be adapted to each other (Van Weele, 2018, p. 38). An additional topic that is usually discussed at this phase, is whether the contract will be awarded on a "fixed-price or cost-reimbursable basis" (Van Weele, 2018, p. 38). When discussing a "fixed-price" contract, the work is predetermined and is delivered up to a predetermined date (Van Weele, 2018, p. 38). Whereas, with a "cost-reimbursable" contract the type and extent are not predetermined (Van Weele, 2018, p. 38).

The second step is “preliminary qualification of suppliers and drawing up the bidders list” (Van Weele, 2018, p. 38). Prequalifications, that the potential suppliers have to meet, are created on the basis of the purchase order specification (Van Weele, 2018, p.38). Afterwards a list of suppliers who could potentially fulfill the request and meet the criteria are listed in the so called “bidders’ long list” (Van Weele, 2018, p. 38).

The third step is “preparation of the request for quotation and analysis of the bids received” (Van Weele, 2018, p. 38). When the bidders list has been compiled, all companies on the list are sent a request for information (RFI) (Van Weele, 2018, p. 38). The information sent to the buying firm usually includes previous work and preceding experiences, as well as other information (Van Weele, 2018, p. 38). At this stage, a tour of the supplier’s facilities or audit of the supplier might be needed to obtain an overview of the supplier’s competences (Van Weele, 2018, p. 38). On the basis of the collected information a few suppliers are selected and a request for quotation is sent out (RFQ) (Van Weele, 2018, p. 38). This situation is a so called “tender”, where a purchaser requests a quotation from possible suppliers (Van Weele, 2018, p. 39). If there is no appropriate number of prequalified suppliers, additional suppliers have to be found through supply market research (Van Weele, 2018, p. 39). After the bids have been received the procurement department will vet the quotations financially and technologically (Van Weele, 2018, p. 39). Additionally, the quotations need to be checked from several different angles, i.e. legal or logistical, and these elements need to be weighed (Van Weele, 2018, p. 39). According to Van Weele (2018, p. 39), this step concludes with a “supplier selection proposal”, which comprises of the choice made for a particular supplier, the applied classifications, and the received and vetted quotations. In some cases, additional examinations might be necessary if strategic or integral suppliers are to be selected (Van Weele, 2018, p. 39).

The last step is the “selection of the supplier” (Van Weele, 2018, p. 38). When one supplier is selected to be commissioned, the shipment is discussed (Van Weele, 2018, p. 39). Moreover, the companies, whose bids have not been selected, are notified about the reasons why they were not selected (Van Weele, 2018, p. 39).

2.4.1.3. Setting up a contract that governs all applicable terms, clauses, and conditions

The third step in the Linear Purchasing Process by Van Weele (2018, p. 29) is called “Contract Agreement”. Once a selection for a particular supplier has been made, a contract has to be drawn up (Van Weele, 2018, p. 39). The contents and nature of the contract depends on the purchased goods or services (Van Weele, 2018, p. 39). Moreover, specific legal technicalities and conditions will vary, depending on the parties involved and their respective company policies, business environment and culture (Van Weele, 2018, p. 40). The agreement between the buying and supplying party usually covers the following aspects: “Prices and Terms of Delivery”, “Terms of Payment”, Penalty Clauses and Warranty Conditions“, and “Other Arrangements” (Van Weele, 2018, pp. 40-41).

Under “Prices and Terms of Delivery” van Weele (2018, p. 40) advises the buying party to insist on a fixed price, which has been developed through negotiating or competitive bidding. Furthermore, in an optimal scenario the supplier should carry all the risks involved, unless this has not been prohibited contractually (Van Weele, 2018, p. 40). If machinery is bought, Van Weele (2018, p. 40) recommends that optional costs for servicing spare parts and prospective deliveries should be negotiated. Also, when sourcing internationally, currency risks and compensation for it should be discussed in the final contract (Van Weele, 2018, p. 40).

“Terms of Payment” reviews the payment practices depending on different situations (Van Weele, 2018, p. 40). Typically, payment for industrial goods or machinery takes place in installments (Van Weele, 2018, p. 40). One installment method is to tie the payout of an installment to the supplier’s performance, i.e. a certain percentage of the final work is completed, and the supplier received a certain percentage of the final sum (Van Weele, 2018, p. 40). Another method of payment is paying the entire sum in advance (Van Weele, 2018, p. 40). In this case advance payments should be protected either by a concern guarantee or a bank guarantee (Van Weele, 2018, p. 40). Additionally, the point when ownership is transferred should be defined in the contract (Van Weele, 2018, p. 40).

The next aspect that should be covered in the purchase agreement is “Penalty Clauses and Warranty Conditions” (Van Weele, 2018, p. 40). Van Weele (2018, p. 40) points out that in several large companies the general purchase conditions oblige the suppliers to deliver their goods or services in good quality, free of faults and defects, and conforming to previously agreed upon specifications, requirements, designs, graphics etc. and that the delivered goods or services fulfill their planned function (Van Weele, 2018, p. 40). Additionally, the purchase conditions concern themselves with the raw materials used and the personnel employed to manufacture the goods (Van Weele, 2018, p. 41). Moreover, it needs to be addressed in the contract what legal system applies to the contract (Van Weele, 2018, p. 41). Typically, the supplier decides what legal system applies and choose the one where he is situated (Van Weele, 2018, p. 41). Furthermore, the performance of the delivered goods or services should be included as well as possible corrective measures, cost recovery, refusal of the delivered goods, liabilities, warranty period etc. (Van Weele, 2018, p. 41). Special aspects concern themselves with spare parts, servicing, and support over the technical or economic lifespan of the product (Van Weele, 2018, p. 41).

When referring to “Other Arrangements”, Van Weele (2018, p.41) mentions “insurance and safety regulations”, as well as specific terms of delivery and “third party contracting”.

2.4.1.4. Ordering the goods in the agreed upon specification, quantity, and quality, at the agreed upon price, and with an expected delivery date

The fourth aspect in Van Weele’s (2018, p. 29) Linear Purchasing Process is called “Ordering”. Once a contract has been agreed upon, an order is placed (Van Weele, 2018, p. 44). Different situations, for example routine buying ones, call for different agreements, i.e. call-off agreements (Van Weele, 2018, p. 44). A typical purchase order is usually issued electronically, once a purchase order requisition has been created (Van Weele, 2018, p. 44). When manufacturing or stock goods are concerned, a materials requirement planning (MRP) system produces the purchase order requisition, based on comparing current inventory levels with the needed inventory levels for production (Van Weele, 2018, p. 44). Sophisticated MRP systems automatically convert the purchase requisition order into a purchase order (Van Weele, 2018, p. 44). When no MRP system is employed, the purchase order requisition has to be done manually by filling out a form, which are forwarded to the procurement department, once they have been approved by the controller of the budget (Van Weele, 2018, p. 44). In order for purchase order to be successful, it is essential for the included information to be precise (Van Weele, 2018, p. 44). According to van Weele (2018, p. 44) a purchase order will include the following information: “order number, concise description of the product, unit price, number of units required, expected delivery time or date, delivery address and invoicing address”.

2.4.1.5. Following up on the order and monitor whether everything goes according to the prespecified plans and conditions

The second last step in Van Weele’s (2018, p. 29) Linear Purchasing Process is called “Expediting”. Expediting concerns itself with following up on placed orders through closely monitoring and checking, whether all aspects of the order are being performed as planned (Van Weele, 2018, p. 7). If all aspects related to the preparation and information of the order have been conducted appropriately there will be considerably less need for and amount of expediting

(Van Weele, 2018, p. 44). Van Weele (2018, p. 44) distinguished between three types of expediting used in practice: “routine status check, advanced status check, and field expediting”. Additionally, van Weele (2018, p. 44) discusses “exception expediting”, which triggers if the internal customer informs the buyer of the good not being delivered on time. Afterwards the buyer must take immediate action in order to evaluate whether this delivery delay will cause problems for the production processes or day to day operations (Van Weele, 2018, p. 44). Van Weele (2018, p. 44) does not recommend this type of expediting, because buyers are only reacting to problems as they occur.

One preventative approach is the “routine status check” (Van Weele, 2018, p. 44). When using the “routine status check”, the purchaser contacts the supplier several days in advance of the schedule delivery date to check whether the delivery is going to be delivered according to plan (Van Weele, 2018, p. 44). Another more time-consuming method is “advanced status check” (Van Weele, 2018, p. 44). Typically, this method is applied for crucial suppliers, as well as crucial production materials (Van Weele, 2018, p. 44). When using this approach, purchaser regularly check the advancement of the supplier against the contractual timetable that has been previously agreed upon (Van Weele, 2018, p. 44). If an order or contract is deemed highly important to the production or operation of the company, it might be decided to send a dedicated inspector to the supplier (Van Weele, 2018, p. 45). This approach, used for high value and high uncertainty contracts, is called “field expediting” (Van Weele, 2018, p. 45). Furthermore, once the ordered goods arrive at the buying company’s facilities, they need to be checked whether they meet the previously agreed upon prerequisites and conditions (Van Weele, 2018, p. 45).

2.4.1.6. Evaluating whether the supplier met the expected standards

The last step in Van Weele’s (2018, p. 29) Linear Purchasing Process is called “Evaluation”. The responsibilities of the buyer do not end with the acquired goods or services being used in day-to-day operations (Van Weele, 2018, p. 45). Several aspects have to be considered by the purchaser, among them warranty issues, lesser and exuberant labor, penalty clauses (Van Weele, 2018, p. 45). Additionally, all files regarding the order have to be updated and if applicable archived (Van Weele, 2018, p. 45). Furthermore, supplier and project evaluation need to be completed and forwarded to the appropriate positions (Van Weele, 2018, p. 45). By having extensive records on their suppliers, companies can reduce their supplier base and retain suppliers with a proven and meticulous track record (Van Weele, 2018, p. 45).

2.4.2. Segmenting the purchasing process in operational, tactical, and strategic elements

The aforementioned purchasing process is very detailed and describes every single step, but each step is usually not conducted by the same individual and the importance of each step varies significantly. Steinrücke and Jahr (2012, p. 261; see Figure 5) use the segmentation operational, tactical, and strategic to distinguish different planning levels. In the following the entire purchasing process will be separated into operational, tactical, and strategic aspects and each aspect will be defined. The segmentation of the purchasing process enables the easier identification of potential room for improvements. This is especially important, since previous studies (i.e. Pellengahr, Schulte, Richard, and Berg, 2016) have shown that with the introduction of Industry 4.0 technologies in purchasing it is expected that the operational aspects of purchasing are likely to be conducted by machines, to a large extent even autonomously. Additionally, the distinguishing of these steps into operational, tactical, and strategic enables a more thorough analysis and helps with maintaining a good overview over the entire process.

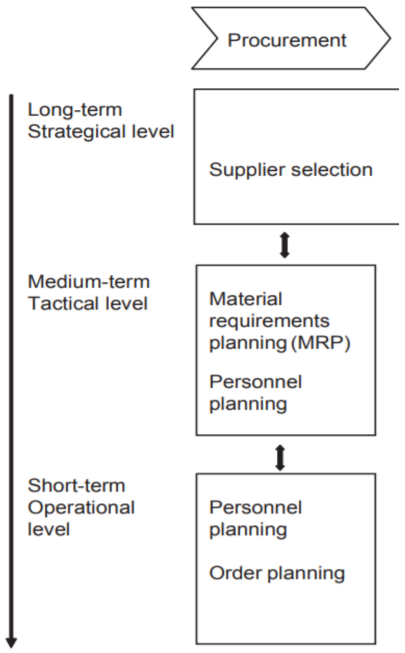

Figure 5: Supply chain planning matrix with a focus put on procurement taken and adapted from Steinrücke and Jahr (2012, p. 261).

2.4.2.1. Operational purchasing involves all activities after the order has been placed

Operational is generally defined as “relating to the activities involved in doing or producing something” (Cambridge Dictionary, n.d.). Operational decisions are the result of previously made tactical and strategic decisions (Misni & Lee, 2017, p. 94). Operational purchasing can be construed as the “completion and realization of the physical provision and supply of goods (Schifferer, 2004, p. 4). Van Weele and Eßig (2017, p. 395) state that the operative level of procurement encompasses all activities that are concerned with ordering and the monitoring of deliveries, including all activities involved in the ordering process, starting with demand and ending with payment. Van Weele (2018, p. 30) highlights that the operational purchasing function focuses primarily on “logistics-administrative” elements. Rozemeijer (2008, p. 205) elaborates that operational activities in purchasing focus on ordering and expediting. Traditionally the operational level has a short-term focus (Steinrücke and Jahr, see Figure 4, 2012, p. 261). Due to its short-term focus and the “immediacy” of operational tasks, it is often prioritized over the more longer-term focused levels (Monczka et al. 2015, p. 177). Additionally, operational purchasing encompasses order planning (Steinrücke and Jahr, see Figure 4, 2012, p. 261). Schifferer (2004, p. 4) explains that operational purchasing concerns itself with material planning, needs recognition, order management, invoice and delivery tracking, and delivery, quality and quantity controlling. Baily et al. (2015, p. 45) name “expediting, records and system maintenance, invoice clearance, requisition handling, enquiries and quotations, price determination and returns” as operational purchasing activities. Rozemeijer (2008, p. 205) lists “ordering of materials, monitoring the deliveries and settling quality disputes on incoming materials” as operational activities.

Based on the previously mentioned literature the following definition of Operational Purchasing was developed and its associated activities are listed:

Operational Purchasing involves all activities after the order has been placed, exemplary activities are: order handling, expediting, problem solving, as well as supplier evaluation on individual project basis (see Figure 6). The distinguishing factor from tactical purchasing is the placing of the order (see Figure 6).

2.4.2.2. Tactical purchasing involves all activities taking place prior to ordering

Tactical is generally defined as “relating to tactics or done in order to achieve something” (Cambridge Dictionary, n.d.). According to van Weele and Eßig (2017, p. 394) the tactical level of purchasing concerns itself with the selection of products, processes, and suppliers. Steinrücke and Jahr (see Figure 5, 2012, p. 262) describe tactical planning in a supply chain as the link that transforms long-term goals into medium-term policies for all representatives of the supply chain. The associated time-frame ranges from several months to a year, making its focus the medium-term level (see Figure 5, Steinrücke & Jahr, 2012, pp. 260-261). Van Weele (2018,

p. 30) depicts the tactical purchasing function as having primarily a “technical-commercial” focus. Rozemeijer (2008, p. 205) clarifies that tactical purchasing activities concern themselves with the “involvement of purchasing in product, process and supplier selection and contracting (i.e. sourcing)”. Although Obanda (2010, p. 27) uses purchasing and procurement interchangeably, he characterizes tactical procurement (tactical purchasing) as concerning itself with the “specification (of goods, works and services); selecting and contracting of suppliers”. Another distinguishable difference is that tactical purchasing decisions have a medium-term focus, ranging from a year up to several years (Van Weele and Eßig, 2017, p. 395). Moreover, tactical purchasing decisions are cross-functional, since effective decision-making processes require close cooperation with the different departments within a company (Van Weele & Eßig, 2017, p. 395). Furthermore, associated purchasing tasks include material requirements planning (MRP) and personnel planning (see Figure 5, Steinrücke and Jahr, 2012, p. 261). De Boer, Holmen and Pop-Sitar (2003. p. 911) cite need specification, selection of appropriate suppliers, and bargaining and contracting as tactical purchasing activities. Gelderman, Semeijn and de Bruijn (2015, p. 221) also designate specification, supplier selection, and contract agreement as tactical purchasing.

Based on the previously mentioned literature the following definition of Tactical Purchasing was developed and its associated activities are listed:

Tactical Purchasing involves all activities taking place prior to ordering, exemplary activities are: outline the technical and functional specifications, checking suppliers’ technical capabilities, pre-screening as well as selecting suppliers, requesting the quotations, negotiation, formulating the contract (see Figure 6). The distinguishing element from operational purchasing is the placing of the order (see Figure). Furthermore, although evaluation is allocated to the operational part of purchasing, tactical purchasing is also part of it, as the entire dealings with the supplier are evaluated.

2.4.2.3. Strategic purchasing involves all activities on management level that extend outside the purchased project level

Generally strategic is defined as “helping to achieve a plan, for example in business or politics” (Cambridge Dictionary, n.d.). Theory and practice are not precise when they consider the position addressed with strategy advancement in procurement (Hesping, 2015, p. 35). Zsidisin and Siferd (2001, p. 62) portray strategic decision making as having a “corporate-wide perspective”. Focusing on procurement and purchasing centered literature, Schifferer (2004, p. 4) describes strategic purchasing as “all activities that concern themselves with the planning, designing, implementation and controlling of customer-supplier-relationships”. Carr and Smeltzer (1997, p. 201) define strategic purchasing as ”the process of planning, implementing, evaluating, and controlling strategic and operating purchasing decisions for directing all activities of the purchasing function toward opportunities consistent with the firm's capabilities to achieve its long-term goals.“ Cavinato and Kauffman (2000, p. 66) describe strategic purchasing as having a focus on “supplier evaluation, selection and development “. Strategic Purchasing activities are limited to those that affect the status of the company within supply and customer markets (Rozemeijer, 2008, p. 205). The strategic purchasing level has a long-term focus (Steinrücke & Jahr, 2012, p. 261; see Figure 5). Additionally, the decisions made at the strategic level impact the market position of the entire company, due to the long-term focus (van Weele & Eßig, 2017, p. 393-394). Because of the high impact of the strategic purchasing decisions, they are usually made at the top-management level (van Weele & Eßig, 2017, p. 393-394). Monczka et al. (2015, p. 177) point out that due to the long-term focus of strategic purchasing and the “immediacy” of the other levels it is often ignored or is not of primary concern.

Based on the previously mentioned literature the following definition of Strategic Purchasing was developed and its associated activities are listed:

Strategic purchasing involves all activities on management level that extend outside the purchased project level, exemplary activities are: managing of supplier relationships (including development and conducting the evaluation), checking decisions made at the operational and tactical level, incorporating the firm strategy in the procurement strategy (see Figure 6). Generally, strategic purchasing is involved in the majority of the operational and tactical elements of the purchasing process, due to its overseeing function and bearing the overall responsibility.

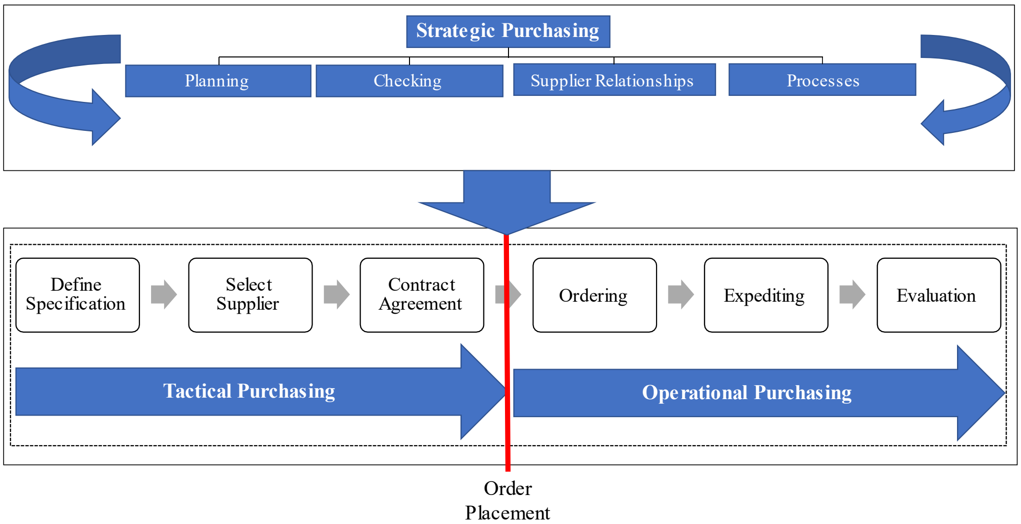

Figure 6: Purchasing Process segmented into operational, tactical and strategic elements, adapted from van Weele (2018, p. 28)

2.4.3. Industry 4.0 applications in the segmented purchasing process

The segmented purchasing process is suitable for distinguishing between different areas of application of Industry 4.0 in purchasing. In the following part the most suitable Industry 4.0 aspects in operational, tactical, and strategic purchasing will be described (see Table 1).

Operational	Tactical	Strategic
Big Data and Big Data Analytics	Big Data and Big Data Analytics	Big Data and Big Data Analytics
Cloud (Computing)	Cloud (Computing)	Cloud (Computing)
M2M	Artificial Intelligence	Artificial Intelligence
CPS		
Artificial Intelligence		

Table 1: Applications of Industry 4.0 in purchasing

In operational purchasing the most useful aspects of Industry 4.0 are Big Data and Big Data Analytics, Cloud (Computing), M2M, CPS. Big Data and Big Data analytics can be used to analyze the received data and compare with data from the past during the expediting and the evaluation phase (Schoenherr & Speier-Pero, 2015, p. 122). The cloud can be used for real time exchange of data with the suppliers and other internal stakeholders (Velásquez et al., 2018, p. 264). M2M and CPS can be used to receive data and monitor progress during the production, shipping and warehousing process. Artificial intelligence can be used to monitor and perform the entire operational aspect of purchasing (Min, 2010, pp. 21-22; Glas & Kleemann, 2016, p. 62; Kleemann & Glas, 2017, pp. 9–10).

In tactical purchasing Big Data and Big Data Analytics, Cloud (Computing), and Artificial Intelligence are the most practicable Industry 4.0 technologies. Big Data and Big Data Analytics can be utilized to draft the needed specifications through older and new data, compare the received current offers, as well as comparing them to offers received in the past (Schoenherr & Speier-Pero, 2015, p. 123). The obtained information from the analysis can be used to select the most suitable supplier during the supplier selection phase (Schoenherr & Speier-Pero, 2015, p. 123; Kleemann & Glas, 2017, p. 10; Klünder et al., 2019, p. 6). Through the cloud companies have the ability to communicate and exchange data with the suppliers (Velásquez et al., 2018, p. 264), regarding the specifications and the quotations. Artificial Intelligence in connection with the other technologies can monitor the entire process, perform the analysis of the received offers and assist during negotiation, as well as negotiate on its own (Min, 2010, pp. 21-22; Bienhaus & Haddud, 2018, p. 974).

In strategic purchasing the most applicable Industry 4.0 technologies are Big Data and Big Data Analytics, Cloud (Computing), and Artificial Intelligence. Big Data and Big Data analytics can be used to plan demand, assist with monitor the purchasing process for potential disruptions, deliver and compare and analyze data on supplier relationships, and aid during the formulation of the purchasing strategy (Schoenherr & Speier-Pero, 2015, p. 123; Klünder et al., 2019, p. 6). The Cloud can be used to exchange relevant key figures and documents with internal stakeholders, as well as support the planning with its computational capabilities (Velásquez et al., 2018, p. 262). Artificial Intelligence can provide 24/7 monitoring capabilities of critical supply chains, forecasting, and assist or perform supplier evaluations (Min, 2010, pp. 21-22).

2.5. Purchasing highly specialized (network construction) services differs drastically from purchasing materials and regular services

Over the years the portion of services in the overall purchasing portfolio has been increasing and many services that make up a substantial part of the companies’ value propositions to its clients have been outsourced to external companies (Van Weele, 2018, p. 81). Moreover, many organizations spend more funds on service procurement, than on procuring goods (Baily et al., 2015, p. 455). Purchasing services is to be considered as one of the most difficult tasks of the purchasing department (Dobler & Burt, 1996, p. 409). Generally, most purchased services revolve around support activities, such as financial services, cleaning services or consultancy services (Van Weele, 2018, p. 81). Even ordinary services, such as lunchroom or custodian services have a considerable impact on the overall mood and attitude of the entire staff (Dobler

& Burt, 1996, p. 409). Therefore, it is important to distinguish between different types of services.

2.5.1. Purchasing services requires a different approach than purchasing goods

Most notably, purchasing services differs from purchasing materials and therefore different approaches and measurements have to be used (Smeltzer & Ogden, 2002, p. 67; see Table 2). Yet, the term "service" has no universally accepted definition (Edvardsson et al., 2005, p. 107; Moeller, 2010, p. 359). Additionally, in a service focused literature review Edvardsson et al. (2005, pp. 118-119) not only stress that there is no universal definition of services, but also that the definition is constantly changing, depending on the specific situation, the specific company, and the specific service. Whereas Baily et al. (2015, p. 456) describes services as "(…) any kind of supply where the main component is a task of some kind, rather than the provision of some tangible good or material". Zeithaml et al. (2010, p. 1) define services as "deeds, processes, and performances (…)". Regan (1963, p. 57) construes services as being "(…) either intangibles yielding satisfactions directly (insurance), tangibles yielding satisfactions directly (transportation, housing), or intangibles yielding satisfactions jointly when purchased either with commodities or other services (credit, delivery)". Shostack (1977, p. 73) points out that services are differing majorly from products, as they are experienced, provided, and cannot be stockpiled. Moreover, in a service transaction the customer does not gain ownership of anything (Baily et al., 2015, p. 456).

There may be no clear definition of services, but key characteristics of services have been frequently described over time. Regan (1963, p. 58) lists intangibility, perishability, and heterogeneity as the characteristics of services. Parasuraman et al. (1985, p. 42) only list intangibility, heterogeneity, and inseparability as key characteristics of services. Since the 1980s most scholars have listed four defining characteristics of services, also called IHIP-characteristics, namely intangibility, heterogeneity, inseparability (sometimes called "simultaneity"; see Van Weele, 2018, p. 84) and perishability (e.g. Zeithaml et al., 1985, pp. 33-35; Edvardsson et al., 2005, p. 108; Moeller, 2010, p. 362; van Weele, 2018, pp. 83-84). The first one is intangibility, meaning that services are activities and not physical objects (Edvardsson et al., 2005, p. 113). Therefore, services cannot be touched seen, felt, or tasted prior to being purchased (Edvardsson et al., 2005, pp. 113-114). Additionally, exact service specifications regarding consistent quality are difficult to create (Parasuraman et al., 1985, p. 42). The second characteristic is heterogeneity, which describes the variability of the quality of the services, namely that the quality depends on the producer of the service, as well as the circumstances under which the service is performed, and the customer who requested the service (Zeithaml et al., 1985, p. 34). Moreover, even if a service is performed by the same producer, the performance itself may fluctuate from day-to-day (Zeithaml et al., 1985, p. 34). The third characteristic of services is inseparability, which details the simultaneous action of production and consumption of services (Zeithaml et al., 1985, p. 33). Yet there are many services where the simultaneous production and consumption is not applicable, e.g. car repairs or financial services, therefore this characteristic is hard to generalize, but nonetheless valid in many cases (Edvardsson et al., 2005, p. 114). The fourth characteristic of services is perishability, which describes that services cannot be stored (Zeithaml et al., 1985, p. 34). While services cannot be stored in the traditional sense, they can be stored for example within systems, people, or knowledge (Edvardsson et al., 2005, p. 114). In recent years, the IHIP characterization of services has been disputed by several strains of literature as being not an exclusive feature of services, but also being applicable to goods (e.g. Zeithaml et al., 2010, p. 1; Moeller, 2010, p. 359). Van der Valk and Rozemeijer (2009, p. 4) point out that if one assumes that services and goods are not the same, it seems illogical that purchasers have problems with purchasing services. All in all, services possess different characteristics than products (see Table 2) and therefore should be treated differently.

Services	Products
Intangible	Tangible
Usually simultaneous production and consumption	Usually seperate consumption and production
Typically fluctuating level of quality	Ideally steady level of quality
Difficult and laborious to specify	Typically fast and fairly easy to specify
Other departments may take the lead during the purchase process	Purchasing department typically has the lead
Ownership is not transferred	Change in ownership after transaction

Table 2: Contrasting the characteristics of Services and Products

On the basis of the work of Smeltzer and Ogden (2002, p. 67), it is assumed that, purchasing services differs from purchasing materials (see Table 2). As a consequence, purchasers who perform well at purchasing goods may not perform equally well at purchasing services (Smeltzer & Ogden, 2002, p. 67). Additionally, a survey by Van der Valk and Rozemeijer (2009, p. 6) shows that typically purchasers experience three distinct problems while buying services, (1) “specifying the service”, (2) “defining the specific content of a service level agreement”, and (3) “evaluating performance”. In order to avoid these problems, it is advised to obtain explicit information from the potential supplier and afterwards use the obtained information to develop clear specifications in collaboration with the potential suppliers (Van der Valk & Rozemeijer, 2009, pp. 6-7). These actions effectively add two additional steps, which are called “Request for Information” and “Detailed specification” in the purchasing process by van Weele (2018, p. 28), prior to selecting the supplier (Van der Valk & Rozemeijer, 2009, pp. 6-7). Furthermore, in order to successfully purchase the right services, the purchasing department has to work in close cooperation with the involved departments (Van der Valk & Rozemeijer, 2009, p. 7). Moreover, typically “Service Level Agreements” are incorporated in contracts and are used to set the minimum acceptable quality standard for the provided services (Baily, 2015, p. 482; van Weele, 2018, p. 83). These Agreements contain certain key performance indicators, like cost or service level, that allow the assessment, whether the previously agreed upon service level has been met (Van Weele, 2018, p. 83).

All in all, purchasing services represents a great challenge to purchasers, since services have many unique properties that make them hard to compare, specify and measure (see Table 2). Yet, with meticulous pre-definition of the intended outcome and exact service level agreements, purchasing services can be purchased in a cost effective and transparent way.

2.5.2. Purchasing construction services/projects poses several challenges due to the unique nature of their scope

Purchasing construction services differs greatly from the purchasing of regular services or goods (Cavinato & Kauffmann, 2000, p. 939) and therefore the traditional contractual approach from the manufacturing industry is not specific enough for each individual project situation (Cox & Thompson, 1997, p. 128). Purchasing construction services or projects fall into the area of project buying (Van Weele, 2018, pp. 98-99), since construction is a “site-specific 'project-based' activity” (Cox & Thompson, 1997, p. 128). Van Weele (2018, p. 98) stresses that when discussing project buying, the term buying does not suit the actions associated when dealing with projects, but rather uses the terms “contracting” and “contract management”. Nonetheless, for this research the terms buying, or purchasing are used in order to show the connection to ordinary purchasing activities. Generally, construction projects are financially risky, involve complex decisions and are technically complex (Van Weele, 2018, p. 99). Moreover, construction service purchasing is a highly specialized area and requires careful consideration of legal, planning, and financial aspects (Dobler & Burt, 1996, p. 420). As a matter of fact, the financial and legal action required for the individual project may differ from municipality to municipality and therefore have to be conducted separately for each project (Dobler & Burt, 1996, p. 420). Despite the difference in the purchasing of goods and construction services, literature has produced very little in this area and is more focused on the purchasing of construction companies.

One major distinguishing factor of purchasing construction services is the infrequency of the purchases, as generally these purchases are “one-time” and often “first-time” for most purchasers and repetitions are uncommon (Cox & Thompson, 1997, p. 128; Cavinato & Kauffmann, 2000, p. 940). This creates an unfavorable situation for the buying party because contractors perform construction work repeatedly and therefore are acquainted with the entire construction process and the underlying criteria (Cavinato & Kauffmann, 2000, p. 940). As mentioned before, the average purchaser, rarely has to deal with purchasing construction projects and as a consequence is not too familiar with the underlying set of criteria (Cavinato & Kauffmann, 2000, p. 940). Due to the unique nature of each construction project, each individual construction supply chain has to be tailored to the specific factors of the project, creating inefficiencies which lead to extra cost for the buying party (Cox & Thompson, 1997, p. 128). The infrequency of the purchase also shows that while in traditional goods purchasing the relationship with supplier is geared towards a consistent long-term relationship, in construction services procurement the relationship with supplier or contractor is at best recurring (Cavinato & Kauffmann, 2000, p. 940). Furthermore, whereas the standard purchasing of goods is a clear-cut process, the purchase of construction services is inherently more difficult, due to many unknown factors before the project has started (Greenhalgh & Squires, 2011, p. 2). These unknown factors include the duration of the project, quality of labor, and the overall expenses (Greenhalgh & Squires, 2011, p. 2). Additionally, the buying party cannot predict the actual “terms of delivery, budget and the standard of quality” (Greenhalgh & Squires, 2011, p. 2).

Yet, another main distinguishing factor, the high uncertainty of the construction project purchase, also creates two possibilities, namely “risks and opportunities” (Cavinato & Kauffmann, 2000, p. 939). One major source of uncertainty in construction projects are the site-specific ground conditions (Cox & Thompson, 1997, p. 128). The aforementioned risks and opportunities include “intellectual property, labor and craft problems, human motivation, jurisdictional disputes, weather conditions, material coordination, and job complexities” (Cavinato & Kauffmann, 2000, p. 939). One of the biggest risks associated with projects is opportunism, i.e. where each contractual party only seeks to fulfill their own interests (Van Weele, 2018, p. 99). Additionally, projects are also prone to agency problems, which are essentially a collision of interest between buyer and supplier or contractor (Van Weele, 2018, p. 101).

Generally, project or construction purchasing follows the traditional purchasing process (Van Weele, 2018, p. 98; see Figure 3). Despite following the traditional purchasing process, special attention is required during the contracting process at the following stages, "pre contractual stage, contractual stage, contact execution and post contractual stages (Van Weele, 2018, pp. 98-104). Additionally, the purchaser responsible for the project should be involved from the beginning and at every stage (Van Weele, 2018, p. 98).

All in all, the purchasing of construction project is a complicated and challenging task for purchasing departments, especially due numerous factors to be considered, i.e. to the infrequency and scale of the purchase. Yet if such projects are undertaken successfully, they have a lasting impact on the entire organization or corporation. Furthermore, the importance of managing the different internal and external interfaces cannot be underestimated, in order to avoid agency problems and opportunism.

Construction Services
Typically each project is unique
Infrequent purchase
At best recurring relationships with contractors and suppliers
High uncertainty due to various problems, e.g. ground conditions
Prone to agency problems
Construction supply chain has to be tailored to each project

Table 3: Characteristics of Purchasing Construction Services

2.5.3. Purchasing conduit and network construction services/projects (complex services) differs highly from regular construction work

As there is no literature on purchasing network construction projects, analogies from purchasing complex services or complex projects will be drawn. Additionally, due to the lack of network construction centered literature and to illustrate the uniqueness and diversity of network construction, a network profile schematic was developed in cooperation with experts from an energy company (see Figure 8). Network Construction ranges from above or below ground power to fresh water and broadband (see Figure 8). Typically, broadband, and electrical power cables, summarized under the name cable installation, are laid right below the sidewalk (see Figure 8). Whereas, gas, fresh water, heat, wastewater, and rainwater are laid under each site of a road, with waste and rainwater being on one site and the rest on the other (see Figure 8). The aforementioned types of networks are also known under the name of pipe(line) construction (see Figure 8).

According to the Chartered Institute of Procurement complex procurement typically involves complicated or difficult specifications of the purchased product or service (CIPS b, n.d.). Due to the increased complexity of the purchase, the involved risk is considerably higher, especially financially (Caniëls et al., 2012, p. 114), and contracts are considerably more detailed (CIPS b, n.d.). Furthermore, complex construction projects usually involve a high number of different contractors and service providers, as well as a high degree of uncertainty and technological complexity (Olsen et al., 2005, p. 2; Caniëls et al., 2012, p. 114). Moreover, complex procurement projects usually take several years to complete (Olsen et al., 2005, p. 2) and require constant and extensive coordination between all the parties involved in the project (Caniëls et al., 2012, p. 114). In their research on governance in complex procurements in the oil and gas industry Olsen et al. (2005, p. 2) advise fours steps for a complex procurement project, such as building a new offshore platform: (1) "engineering", (2) "fabrication", (3) "installation", and (4) "commissioning". When comparing these steps with the ones for a regular construction project they are quite similar, as both involve a lot of pre-planning and pre-engineering, the only major different step is the commissioning one, where the platform is moved into position.

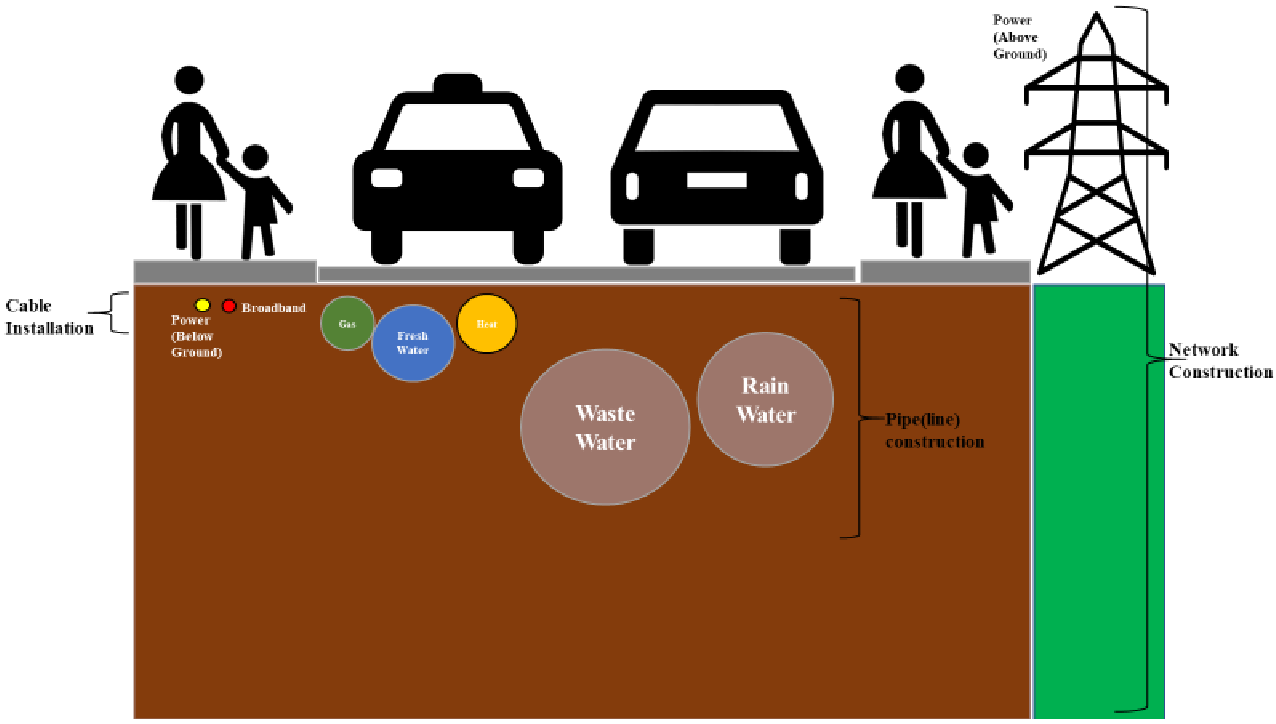

Figure 7: Network Construction Profile

All of the various possible problems and risks in complex purchasing projects make it difficult to achieve previously set financial and time related goals (Caniëls et al., 2012, p. 114). Moreover, opportunism, like in conventional construction projects (Van Weele, 2018, p. 99), represents a serious challenge in complex purchasing projects, as it will have a damaging effect on the collaboration and mutual effort of all companies involved in the project (Caniëls et al., 2012, p. 114). Companies should employ various governance mechanisms to avoid or decrease opportunism in their complex purchasing projects (Caniëls et al., 2012, p. 114). These governance methods are, "Price agreements and incentives anchored in contracts;" "Hierarchical mechanisms, based on control and authority"; "Relational governance mechanisms, based on trust" (Caniëls et al., 2012, p. 114). Caniëls et al. (2012, p. 120) stress that these governance measures are only successful in safeguarding a successful complex purchasing project, when they are applied in conjunction with each other.

Complex Services
Highly detailed contracts
Single projects can involve several contractors and suppleirs
Projects can take several years to complete
Previously set time and financial goals can be difficult to achieve
Wide range of uses, ranging from broadband cables to waste water
Prone to opportunism related problems

Table 4: Characteristics of Purchasing Complex Services

All in all, complex projects (network construction projects) involve several unique characteristics (see Table 3), which call for special attention during conduction of the project. it is imperative to ensure a meticulous planning and governance during network construction projects, because due to the nature of these projects mistakes in the planning phase can prove to be costly and time consuming. Furthermore, mistakes and problems during the constructions of such project can cause far reaching problems for the general public, as well as companies, since energy and water networks ensure our personal and professional everyday lives.

	Materials Purchasing	Service Purchasing	Complex Service Purchasing
Complexity	Varies from high to low	Varies from high to low	Typically high
Uknown Factors	Not applicable	Typically low, yet quality may differ	High
Storage	Usually possible	Not possible	Not possible
Specification	Precise	Difficult and problematic	Difficult
Variability of Quality	Low	High	High

Table 5: Differences in the purchasing of materials, services, and network construction services

2.6. Purchasing Network Construction in the light of Industry 4.0

The next industrial revolution will be unique in several ways, it will be the first industrial revolution to announce itself prior to its occurrence (Drath & Horch, 2014, p. 56), it is likely to change how business is conducted and goods are produced. Several new technologies will be introduced, among them are "Cyber-Physical Systems" (CPS), "Machine-to-Machine Communication", "(Industrial) Internet of Things" (IoT), "Big Data", "Cloud Computing", and "Smart Manufacturing" (Wang & Wang, 2016, p. 2; Bechtold, Lauenstein, Kern & Bernhofer, 2014, p.

4; Schiele, 2016, p. 16; Rojko, 2017, p. 77; Smit, et al., 2016, p. 22). And existing technologies such as Artificial Intelligence will gain more presence in our workplace. Among the several areas these technologies will influence, and change is purchasing. Purchasing is one of the key activities of almost every company. Over the years several different scholars have described and labelled the process of purchasing goods and services, with the purchasing process by Van Weele (2018, p. 28) emerging as the most dominant one. This process can be segmented into operational, tactical, and strategic elements. Operational purchasing concerns all activities after the order is made. Tactical purchasing concerns all activities prior to ordering. The central point of distinction between operational and tactical elements is the order placement. Strategic purchasing concerns itself with all activities on management level that extend outside the purchased project level. This segmentation enables a better division of labor and clear responsibilities. Furthermore, by segmenting the purchasing process new technologies and software can be tailored better towards the different scope of activities.

Among the areas in purchasing that have almost never been covered is the purchasing of network construction. Network construction involves several different aspects, ranging from broadband cables to wastewater pipes. These types of construction projects are unique in their nature as they are regional in their scope, highly complex, involve several contractors and suppliers, involve large amounts of planning and are typically capital intensive. Without proper network construction our everyday lives would cease to exist, as we all rely on a supply with power and water, as well as wastewater treatment.

On the basis of the previous review of literature and its consideration a research model is developed (see Figure 8).

The conducted literature review and the proposed research model (see Figure 8) lead to the following propositions:

Proposition 1: The purchasing process can be clearly classified into operational, tactical, and strategic aspects.

Proposition 2: Industry 4.0 solutions can be clearly linked to a specific area of purchasing (operational, tactical, and strategic).

Proposition 3: Good data quality is the basis of any implementation of Industry 4.0 solutions in purchasing.

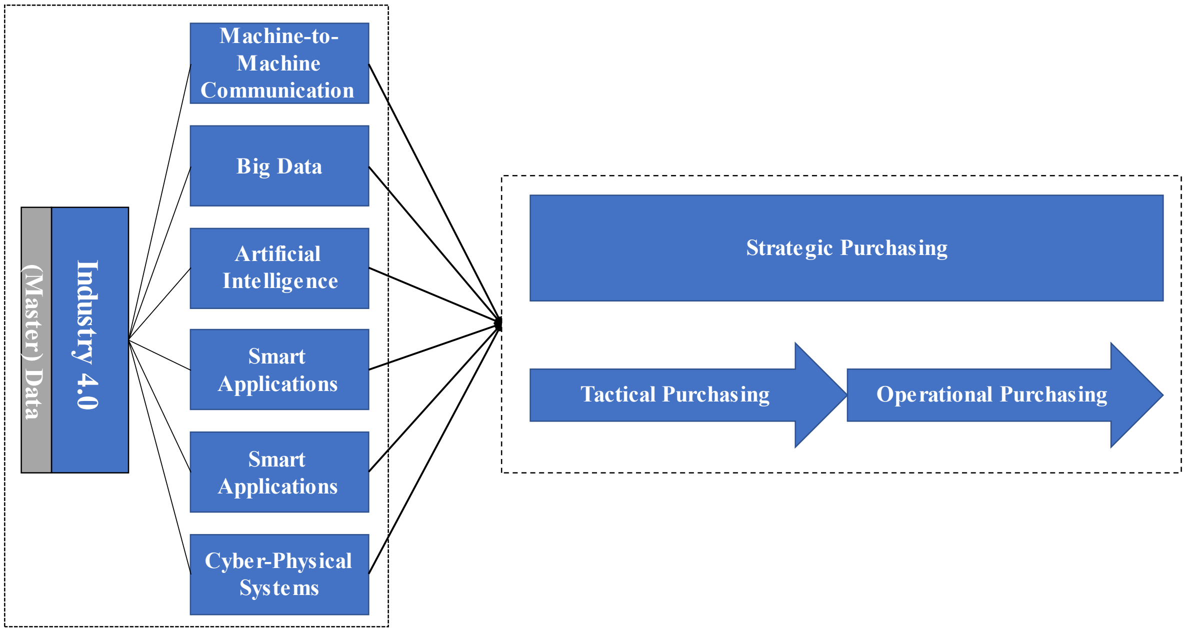

Figure 8: Research Model

3. Semi-structured qualitative interviews will be used to obtain the desired information

3.1. Qualitative Research is especially suited to obtain knowledge on how participants view a certain phenomenon

This thesis aims to aid with the challenges purchasers of complex services face and whether Industry 4.0 is able to support and ease their day-to-day tasks. Furthermore, this thesis is outlining possible applications for Industry 4.0 technologies in purchasing net-work construction. In order to achieve this, the relevant theoretical considerations have to be supported by practical findings. The theoretical considerations have been conducted in the previous part. In order to complete this research practical data has to be collected and analyzed. The following part elaborates how the data was collected and what methods and techniques were employed in the process.

Denzin and Lincoln (2017, p. 43) define qualitative research as “a set of interpretive, material practices that make the world visible”. Furthermore, Denzin and Lincoln (2017, p. 43) elaborate that qualitative research studies “(…) things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them.” In social sciences and psychology qualitative research has been used for a long time as a research instrument to analyze specific problems (Flick, 2009, p. 17). As both social sciences and psychology matured, research methods that focused on quantifying and standardizing gained more attention

(Flick, 2009, p. 17). Qualitative research is a universal research tool, as it allows for a variety of sources, ranging from interviews, newspapers, to videos (Corbin & Strauss, 2008, p. 27; Denzin & Lincoln, 2017, p. 43). In addition, Qualitative research is especially suited to extract information from the participants, regarding how they view a certain topic or interpret certain phenomenon (Atieno, 2009, p. 16). Typically, Qualitative Research takes place in the field, as that is where the participants make or have made their experiences regarding the researched problem or situation (Creswell. & Creswell, 2018, p. 257). Central to qualitative research is the aim of understanding (Misoch, 2009, p. 25), and in particular how the studied phenomena function (Tetnowski & Damico, 2001, p. 22). Moreover, qualitative research aims to obtain new views on existing knowledge and offers an accurate and thorough depiction (Atieno, 2009, pp. 16-17). Additionally, by allowing for an exact level of differentiation qualitative analysis enables more attention for rare phenomena (Atieno, 2009, p. 17). In contrast to quantitative research, qualitative research is focused on highlighting the experiences of the participants and does not focus on statistical elements, but rather on contents (Misoch, 2015, p. 2). It is imperative for Qualitative Research that the researcher studies the phenomenon in question without any bias and free of preexisting reservations, as the researcher is central to the research, as he serves as data collector and data interpreter (Tetnowski & Damico, 2001, pp. 22-23). If bias or reservations are present, the researcher is obliged to acknowledge them and try to minimize them as much as possible (Tetnowski & Damico, 2001, p. 23). A drawback of qualitative research is the lack of reliable scalability, due to the small scale of the research population and because qualitative research does not investigate whether a phenomenon can be attributed to chance or is statistically significant (Atieno, 2009, p. 17). Other criticisms of Qualitative Research include the problematic reproducibility of certain results, as they highly depend on the researcher, results are difficult to generalize, and that the results are basically a collection of observations and impressions, which are prone to researcher bias (Mays & Pope, 1995, p. 109). By putting an emphasis on the participants (Misoch, 2015, p. 3), qualitative research is especially suited for this thesis, because of the importance of the practical views on the purchasing process. On the basis of the aforementioned considerations qualitative research methods have been selected as the most appropriate for the given scenario.

3.2. Methods: Semi-Structured Interviews are most applicable to the scenario of this thesis

One form of Qualitative Research are interviews (Britten, 1995, p. 251; Misoch, 2015, p.13; Denzin & Lincoln, 2017, p. 59). Interviews are a form of asymmetric communication, where the researcher assumes the role of the inquirer and listener, whereas the participant takes the role of the answerer and teller (Misoch, 2015, p. 13). It is important to note that acquiring interviewees is typically rather difficult (Qu & Dumay, 2011, p. 248). Qualitative interviews are an effective and adaptive qualitative research tool, that enables researchers to discover fields and scopes regarding their research (Britten, 1995, p. 253). Interviews are a more efficient data collection method than i.e. quantitative surveys (Bogner, Littig, & Menz, 2009, p. 2). Additionally, (expert) interviews are helpful, as they do not require having access to a large pool of possible participants (Bogner, Littig, & Menz, 2009, p. 2).

There are three different types of interviews, namely: structured or standardized interviews, semi-structured interviews, and open or narrative interviews (Britten, 1995, p. 251; Misoch, 2015, pp. 13-14). Standardized interviews consist of questionnaires, where the possible answers are pre-determined and the participant has to follow the pre-set course and order (Britten, 1995, p. 251; Misoch, 2015, p. 13). Semi-structured interviews comprise of a guideline that specifies the research topic or area and a set of open-ended questions, where the answers are not predetermined (Britten, 1995, p. 251; Misoch, 2015, pp. 13-14). In order to ensure that the semi-interview records the intended data, all relevant topics have to be addressed (Misoch, 2015, p. 14). Open or narrative interviews have no guidelines or predetermined answers, instead the interviewee steers the interview and the researcher only verifies and probes the collected data (Britten, 1995, p. 251; Misoch, 2015, p. 14). The researcher only sets the thematic boundaries and lets the interviewee set their own core themes (Misoch, 2015, p. 14). Semi-structured and open interviews are especially suited to social science research (Misoch, 2015, p. 14). Interviews in general are prone to some problems, among them are: (1) sticking too much to the guidelines, (2) lacking neutrality of the questions and interviewer, (3) overcomplicated and convoluted questions, (4) using closed or “yes or no” questions, (5) evaluating and lecturing the interviewee in case of false or faulty answers, (6) missing key pieces of information in the answers and therefore missing follow-up questions during the interview, (7) deepen answers that are not relevant to the researched topic, and (8) breeching confidentiality (Misoch, pp. 220-228). All in all, interviews are especially suited to obtaining information from participants regarding a variety of aspects and help with gaining a deeper understanding of the researched topic (Misoch, 2015, p. 265).

Another form of qualitative research is the World Café. A World Café, which was first initiated by J. Brown and D. Isaacs in 1995, is a qualitative research method that is used to promote discussions in a setting that is both private and open to uncover opinions and knowledge present in a group or organization (Löhr, Weinhardt, & Sieber, 2020, p. 1). The aim of a World Café is to hear as many opinions and thoughts from participants as possible (Löhr, Weinhardt, & Sieber, 2020, p. 1). Due to the current virus pandemic this approach is not feasible, as grouping a large of amount of people together will pose health risks, as well as the possibility of it violating current health and safety regulations. Additionally, finding a date where all possible participants are able and willing to commit to the duration of the world café would cause further problems. Therefore, a World Café is not feasible for this study.

As the aim of this thesis is to examine the problems and peculiarities of procuring highly specialized services (network construction) which the interviewees are highly experienced in and have special knowledge regarding it, the needed was obtained by conducting semi-structured interviews. All interviewees, that are purchasers were asked the same questions in the same order and the two representatives of construction companies were both asked the same questions in the same order. All interview questions have been designed with the research questions and research topic in mind. The interview questions have been structured in the following way (see A1): At first introductory and background questions are asked in order to ensure that the interviewee feels comfortable answering questions, belongs to the relevant group of purchasers and is knowledgeable about the desired activities by using direct questions. Afterwards the interviewees are asked about the challenges they face during their day-to-day activities and where they are most urgent. Finally, interviewees are asked about how they handle these challenges today and about the prevention of them. Subsequently, the interviewees are asked about Industry 4.0, their knowledge regarding Industry 4.0, the possibility of Industry 4.0 assistance for their tasks, and about the quality of their master data. The interview questions for the two representatives of construction companies were slightly changed, as they were not asked about the proposed classification, and about further optimizations through Industry 4.0 for their day-to-day tasks.

Unlike quantitative research, where the sample needs to mirror certain elements or attributes of the population, qualitative research participants do not have to mirror certain attributes or elements of the population (Misoch, 2015, p. 185). Moreover, participants in qualitative studies should be selected on the basis, whether they can contribute to the research by having the ability to provide insightful answers regarding the research topic and research question (Misoch, 2015, p. 186; Creswell & Creswell, 2018, p. 262). To obtain participants a sampling method has to be chosen. Creswell and Creswell (2018, p. 212) name three types of sampling: random sampling, systematic sampling, and convenience sampling. Random sampling implies the drawing of a random sample, where each person in the population has a comparable chance of becoming a participant in the study (Creswell & Creswell, 2018, p. 212). Moreover, random sampling is not applicable for this research, as the number of possible interviews is small, and the prospective participants have to work as a purchaser at the focal firm. Additionally, due to the focus on the participants ability to provide meaningful answers to the research topic, quantitative research selection methods like random sampling are not advisable for qualitative research (Creswell & Creswell, 2018, p. 262). Systematic sampling is a sampling method where all available participants are listed and an arbitrary starting point is chosen, afterwards every X person is chosen to be a participant (Creswell & Creswell, 2018, p. 212). The variable X is based on the number of participants on the list with prospective partakers of the study (Creswell & Creswell, 2018, p. 212). Systematic sampling is not applicable, as the number of purchasers at the company does not allow for a systematic sample. Convenience sampling means selecting participants based on availability and convenience (Creswell & Creswell, 2018, p. 212). Due to the limited ability to perform random sampling or systematic sampling, convenience sampling was chosen. The selected participants were purchasers with knowledge of network construction and representatives of network construction companies. Due to the smaller sample size in qualitative research, it is essential to be reflective about the selection process (Misoch, 2015, p. 186). Additionally, previous personal experiences have shown how difficult it is to obtain interview partners at firms, where the accessibility is limited and therefore, the willingness to participate is also limited. Matters were complicated further by the fact that while this research was conducted the COVID-19 pandemic was raging worldwide and employees were working increasingly from home, which lowered the willingness to participate further.

Overall, 14 people were questioned. Of the 14 people 12 are purchasers with the remaining two being construction company executives who are in frequent contact with energy providers or municipal utilities companies. Out of the 12 purchasers 3 were the heads of purchasing departments. Furthermore, out of the 12 purchasers 6 are working for the same company. The purchaser’s companies’ sizes varied with the largest one having about 79.000 employees. All companies are conducting their business in the energy sector, with 3 of them being municipal energy providers and 3 being companies with municipal characteristics.

	Position	Company type	Company size
Interviewee 1	Head of the Department	Energy Utility Company	~2600 employees
Interviewee 2	Purchaser	Public Utility Company	~ 5000 employees
Interviewee 3	Deputy head of the Department	Energy Utility Company	~ 79.000 employees
Interviewee 4	Commercial Director	Public Utility Company	~90 employees
Interviewee 5	Strategic Purchaser	Energy Utility Company	~1500 employees
Interviewee 6	Division Head	Sewage Disposal Company	~380 employees
Interviewee 7	Head of the Department	Energy Utility Company	~1500 employees
Interviewee 8	Head of the Department	Public Utility Company	~1900 employees
Interviewee 9	Commercial Director	Construction company	~ 70 employees
Interviewee 10	Purchaser	Energy Utility Company	~ 1500 employees
Interviewee 11	Referent of Materials Management	Energy Utility Company	~ 1500 employees
Interviewee 12	Purchaser	Energy Utility Company	~ 1500 employees
Interviewee 13	Operations Manager	Construction company	~ 130 employees
Interviewee 14	Group Manager	Energy Utility Company	~ 1500 employees

Table 6: Interviewee Characteristics and Data

All interviews were conducted in German and due to the COVID-19 pandemic all interviews except one were conducted via the telephone and one through Microsoft Teams. On average the interviews lasted about 26 minutes, with the shortest interview lasting 15 minutes and the longest interview lasting 44 minutes. The first interview was conducted on the 27th of October 2020 and the last interview was conducted on the 28th of December 2020.

3.3. Transcribing and coding ensure an optimal research basis

The obtained data from the interviews was transcribed and afterwards coded, which is a popular method in qualitative research (Poland, 2001, p. 629). Moreover, coding is an essential part of conducting research (Basit, 2003, p. 144). Additionally, unless collected data has been properly processed, the researcher is not able to draw conclusions regarding the experiences of the participants or the studied phenomenon (Basit, 2003, p. 144). Nonetheless, coding is still just one way of analyzing qualitative data (Saldaña, 2013, p. 2). Transcribing is the process of textualizing the obtained verbal and non-verbal data (Misoch, 2015, p. 249). Transcribing is essential for qualitative research, as the initial research process collects raw data, i.e. audio recordings, that cannot be analyzed further, until it has been transcribed (Misoch, 2015, p. 249). Coding involves attaching labels or categories to different elements of the collected data, the size of the elements can vary from single words to entire paragraphs (Basit, 2003, p. 144). Codes themselves are typically a word or short phrase that summarize and capture the most notable characteristics (Saldaña, 2013, p. 3). Data that can be coded ranges from interview transcripts, videos, email messages, and literature (Saldaña, 2013, p. 3). Central research activities to coding are comparing and enquiring (Basit, 2003, p. 144). It is important to note that coding does not constitute an analysis, but rather is a fundamental part of conducting the analysis

(Basit, 2003, p. 145). Also, coding is not an exact tool, but rather a subjective one, as each code is a product of the interpretation of the researcher (Saldaña, 2013, p. 4). Electronic coding has become more prevalent over the years (Basit, 2003, p. 145). Despite enabling researchers to save time and effort, electronic coding programs do not replace the required manual analytic tasks (Basit, 2003, p. 145).

All in all, the coding process is an essential tool in qualitative research, that when correctly applied ensures a good research process and result. Therefore, the decision will be made to code the data obtained from the interviews.

The audio files obtained from the interviews were manually coded. To code the transcribed interviews the software AtlasTi was used. In the end all codes deemed relevant could be summarized into 4 themes.

4. Results: The interviewees answers center around IT Optimization, Process Optimization, Supplier Management and Change Management

The four themes that emerged from the interview analysis are described last as they are the main focus of the interview questionnaire. The structure will be as follows: firstly, the four emerged themes are highlighted and described, then the obtained data regarding the questions about the positions, purchasing classification, and master data will be described. Moreover, where it is appropriate direct and indirect quotations from the interviewees are given to illustrate the meaning, but since the interviews were conducted in German the quotes have been translated to English. The anonymized interview transcripts can be found in the appendix (see A4).

4.1. IT Optimization focuses on streamlining and simplifying software

During the analysis of the transcripts the theme of IT optimization emerged. Generally, the interviewees focused on a variety of different aspects from IT related topics. This theme in general focuses on simplifying user interfaces and software, introducing a digital marketplace, remote working and the closer integration of suppliers in enterprise resource planning (ERP) software (see Table 7).

Several interviewees mentioned the desire to optimize the user interfaces and software that they use on a day-to-day basis. Essentially the participants were wishing for a more streamlined and simpler experience, mimicking the ease of the software everybody uses for their private purchases. Exemplary for this theme was this quote from Interviewee 2: “(…) contracts and orders are only digital and the immediate sending of the latter through SAP eliminates the ability to check and correct elements." Interviewee 2 also mentioned that suppliers sometimes receive "weird" emails from the ERP-system. Adding to the general theme Interviewee 5 on the other hand focused on the non-digital and manual elements of the software: "(…) we write up the order, we have to print it, sign it and then send it around manually, this severely increases our processing time". Interviewees 2 and 14 exemplary mentioned an improved overview concerning individual software steps, as well as required approvals in different systems. Interviewee 6 added to this: "Then you maybe have multiple systems in use in purchasing and the user always needs to know where he has to do what.". Another important aspect in improving systems was mentioned by Interviewee 5, namely that master data quality is the "central element" for any system, since the system use the master data.

Moreover, the interviewees are desiring a digital marketplace or central tendering platform, especially for small purchases or contracts, that again mimics experiences from private purchases. Interviewee 2 described the problem as follows: "(…) I am already working with several platforms, (…) some have capabilities that the other (platforms) do not have and within Germany alone there are too many different tendering platforms." Interviewee 7 added to this: "Ideally we would have one central tendering platform for Germany, with standardized data and electronic data exchange throughout the entire process". Interviewee 10 focused on minor purchases where the platform would link the requisitioner and the supplier, namely "small purchases could be conducted through digital marketplace, where we (purchasers) would only take action in the case of malfunctions or special circumstances." Interviewee 10 added that these market places would be especially suited to: "small purchases that are outside of framework contracts."

Another element of IT Optimization is the concept of remote working. Although it was not mentioned by the majority of the interviewees, it was deemed important due to the current increased usage of working from because of the corona virus pandemic. Interviewee 11 mentioned during the interview that "systems and software need to be accessible from anywhere in the world" to enable remote working and the working as a purchaser should not be "depending on the location". Moreover, Interviewee 8 expects that "(…) there will flexible office concepts and that we will not have office space for all of our employees". Furthermore, Interviewee 11 adds to this that through Industry 4.0 the need to work place bound will disappear and this will free up time resources.

It was also mentioned that a closer integration of suppliers in ERP systems is desired, especially regarding data exchange and checking available capacities. Interviewee 1 expected that in the future buyers and suppliers will be able to access the same systems without any interfaces and that this will make purchasing more “agile” and “electronic”. Interviewee 9 described the optimization for her construction company as follows: “(…) the interconnection with the IT systems of our clients could be optimized (…)”, namely “we can view our data in the system, but we cannot conduct an independent analysis of our conducted work”, but rather that they have to call people in the purchasing department, and they have to do the analysis for them. Moreover, Interviewee 9 mentioned that “planning materials” are not attached to the other data in the ERP System, but instead are send to different people via email. Interviewee 14 described that it would be beneficial if suppliers could signal or highlight (anonymously) whether they had capacities available, because currently this is only possible to discover through “contacts in the market”. Furthermore, these aspects interplayed with the following theme of process optimization, because when IT elements are changed the corresponding process have to be adapted and vice versa.

IT Optimization
- Simplify user interfaces and software
- Introduce a digital market place for small contracts
- Remote working will increase
- closer integration of suppliers in ERP software

Table 7: Summary of IT Optimization

4.2. Process Optimization focuses on improving the internal and external interconnection and optimizing minor purchases

The second dominant theme that emerged during the coding process is Process Optimization. All in all, this theme is characterized by a focus on simplifying complex processes, improving the internal and external interconnections and interfaces, reducing operational tasks, and improving or automizing the process of making minor purchases (see Table 8). The gist from the theme IT Optimization is also reflected in this theme, namely that through optimization the connection with suppliers is strengthened and interfaces are eliminated. Generally, the interviewees desire more streamlined and interconnected processes that eliminate time intensive manual tasks and enable them to focus on more important tasks.

A frequently mentioned aspect is the area of minor purchases and the complexity of the associated processes, as well as complex processes where the core purchases are rather simple. Interviewee 7 described the situation as follows: “(…) in our company we have 34.000 orders every year” and “it would be great if had a sort of small request for quotation”. Interviewee 7 then expressed the wish to have a sort of commercial "eBay Classified", where only certified suppliers can accept these contracts. This aspect interplayed with the IT Optimization theme, where a central aspect is a digital market place or central tendering platform. Interviewee 10 described a similar problem and solution: "These processes of making minor purchases (…) could be digitally simplified" and "(…) in the future one could perform these minor purchases through digital marketplaces.". Furthermore, Interviewee 10 stated: "We have many complex processes for simple purchases(...)" and that this is the main element he would optimize. Interviewee 14 also mentioned that we would like to have an automated purchasing process for certain minor purchases. An important aspect that was been mentioned by Interviewee 10 is that in his opinion processes should be optimized in conjunction with IT Optimizations as they are both heavily connected. In summary, it can be stated that the interviewees wanted to limit their involvement in operational aspects and minor purchases. Also, they would like to automate the general operational aspects and the purchasing process for these minor purchases.

Among the most mentioned aspects for potential improvement is interconnection. The area of optimizing interconnection interplays with the area of optimizing operational aspects and automizing minor purchases as both aspects rely heavily on interconnection. Interviewee 3 specifically mentions that he wishes for less operational tasks as well as an optimization of these tasks. Moreover, he specifically states that often times the same documents are exchanged with the same partners in network construction. Interviewee 6 describes a similar aspect, namely the "(…) communication with the supplier (…)" as a potential area for optimization. According to Interviewee 6 this already starts at the "transmission of an order or invoice (…)". This is reflected by this excerpt from Interviewee 5 regarding an area that needs optimization: "(…) the area of interconnection, interconnection within our company and external interconnection outside of our company." Interviewee 5 also points out that they are interconnected with their suppliers, but that they are still sending PDF files back and forth. Interviewee 7 goes into greater detail: "(…) Once you have completed the order in the ERP-System (…) the PDF data is exchanged through email. This is the standard operating procedure." Furthermore, interviewee 7 describes that the supplier cannot use their data and that they cannot use the incoming data from the supplier and have to check the data manually. This aspect is mirrored by Interviewee 9, a representative of a construction company, who describes her optimizations regarding the contact with utility companies as follows: "(…) Things that could be optimized are the IT interfaces, the connection of our IT with the client." Furthermore, Interviewee 9 also gives an example, namely that the data they receive from the utility companies is not compatible with their software and vice versa. Moreover, Interviewee 9 also mentions that the main form of data exchange still takes place via email, especially since some files are sometimes missing within the tendering platform. This is mirrored by this statement from Interviewee 12: “(…) Our Europe-wide tenders are not entirely digital but is still based on sending PDF files back and forth.” Moreover, Interviewee 1 has similar thoughts, but describes this as a part of his future purchasing scenario: “(…) Interfaces are eliminated and that contracts and feedback is sent back and forth in real time. “All in all, the interviewees wish for an improved internal and external interconnection that includes the elimination of interfaces as well as a potential automatic data exchange.

Process Optimization
- Simple purchases have complex processes
- Reduction of external and internal interfaces
- Reduction of operational tasks
- Automizing minor purchases

Table 8: Summary of Process Optimization

4.3. Supplier Management focuses on managing and training the supplier base to optimally prepare them for the upcoming developments

One of the minor themes that emerged during the coding process is Supplier Management. Network Construction purchaser face four important challenges, namely a lack of suppliers, regional contractors dominate, limited IT capabilities at suppliers, and limited capacities of suppliers (see Table 9). This theme is characterized by the need for utility companies and energy providers to conduct intensive supplier management in order to be able to implement new or updated ERP systems and maintain competition among their suppliers.

Generally, there was a shortage of suppliers that are able to conduct the necessary tasks, as well as limited capacities at existing suppliers. Interviewee 1 illustrated this very well as he describes that his department is limited in terms of awarding contracts by the capacities of the suppliers and therefore carefully looks after their main contractors. Interviewee 5 saw more intensive supplier management as the “biggest lever” that they have, namely making use of more “collaborative software, like a shared cloud” to exchange files. Interviewee 1 mentioned a similar aspect:” we are looking closely after our suppliers, so that the capacities that they can offer us are used optimally”. Furthermore, Interviewee 1 pointed out that they have to care for and manage their suppliers well, simply for the lack of capacities in the market.

Additionally, according to the interviewees network construction is a regional business, where only large contracts attract national suppliers. Furthermore, Interviewee 1 explained that for the majority of their projects they are limited to regional contractors, because it would not be feasible to employ contractors who are not from within his state. Interviewee 7 supported this by stating that if the contract is large enough national supplier bid on contracts, but that generally:" the majority of our construction projects are smaller and it is a regional business, (…) 50 km to 100 km distance wise. And they only drive 100 kilometers if the contract has six-figures".

Furthermore, the interviewees mentioned that the smaller regional construction companies often times have difficulties and limited IT knowledge, which results in labor intensive micromanagement of contracts. Interviewee 7 depicted the problem that the main form of communication with suppliers still heavily relies on "emails with exchanging PDF files", despite completing the "order process within an ERP-system". Interviewee 2 added to this theme that: "(…) especially smaller companies have problems with digital tendering processes" and because of that they are bound to "lose" the smaller construction companies. Interviewee 12 mentioned a similar challenge: "(…) when I sent out requests for quotations through our system (…) I receive no feedback (…) and no offers. This means I am forced to convert all my files to PDFs and attach them to emails". Interviewee 12 attributed this to the lack of IT knowledge of the suppliers. Interviewee 14 mentions a similar problem with smaller suppliers, where "they have difficulties, even when we sent out our requests for quotations via email." Interviewee 2 mentioned another aspect where supplier require assistance, namely the multitude of tendering platforms: "We alone as a purchasing department use multiple tendering platforms (…) and I have talked to a contractor who has to use more than 10 tendering platforms (…).". Moreover, Interviewee 14 also expected that smaller suppliers will be squeezed out the market if the trend of multiple tendering platforms and increasing technical requirements continues.

Supplier Management
- Lack of suppliers and limited capacities at suppliers
- Regional contractors dominate
- Lack of IT capabilities at suppliers

Table 9: Summary of Supplier Management

4.4. Change Management focuses on managing the upcoming developments while accommodating both experienced and younger employees

The last theme that emerged during the coding process is the theme of change management. While this is not necessarily a problem that the purchasers face, it is more an area that will gain importance over the coming years. This theme captures the interviewees thoughts on future developments and changes within purchasing, such as the struggles of a generational change, how to deal with the increasing number of systems, and how their job tasks and purchasing could change over time. Specifically, these challenges also consist of how to involve older and experienced employees within this change and how to facilitate the shift towards a more system-oriented purchaser, while keeping the traditional skills. Furthermore, the interviewees expect these changes to be incremental in nature and build on existing systems and that the implementation of these changes will stretch over a longer period of time.

Several experienced purchasers mentioned that they are not really focusing on the upcoming changes, due to their retirement in the coming years. This was mirrored by Interviewee 14 who mentions: "(…) we have employees who questions these changes and do not back them (…)". Interviewee 14 also mentioned that the changes in purchasing will happen naturally over time as: "(…) older employees retire, younger ones take their place and naturally they have a different focus and had a different education."

Interviewee 6 described the struggle of the increasing number of systems as follows: "(…) The user always has to know where do I have to sign in and what is my next task (…)." Interviewee 5's thoughts captured the shift in focus of purchasers: "(…) In the past purchasers needed technical knowledge, but now they have to understand the systems (…) in order to be able to use and develop them.". Furthermore, Interviewee 5 explicitly stated that: "purchasers will have to orient themselves more towards systems.". Interviewee 10 mentioned that even when systems run smoothly the user has to know what actions he has to perform within the system. Interviewee 12 on the other hand focused more on how to facilitate the change, namely through "(…) forming interdisciplinary teams (…), consisting of IT experts, technicians and purchasers". Interviewee 5 had similar thoughts regarding the facilitation of the change, namely: "(…) we have to make these changes visible (…) and have a software for managing innovations (…)."

The aspect of incremental change over time has also been mentioned several times during the interviews. For example. Interviewee 7 depicts the changing focus of purchasers as happening "step by step". Interviewee 8 goes along the same lines, as he expects that "Industry 4.0 will not spread as fast to that extent within the (…) utility sector".

Change Management
- Generation change
- Innovation and technology management
- Incremental change

Table 10: Summary of Change Management

4.5. All of the purchasers work in the energy sector and know about the classification, but 10 out of 12 view it as not practical

The interview questions 1 and 1.1 of the purchaser questionnaire concern the position and the main focus of their professional activities. The positions of the interviewees range from being a strategic purchaser to being the head of an entire purchasing department. Out of the 12 interviewed purchasers 8 are in leading positions. All of the purchasers worked for companies that are conducting their business within energy and utility sector. Some of the purchasers worked for public utilities companies or semi-public utility companies. The two representatives of construction companies were also in leading positions at their companies. The respective construction companies both specialized in network construction for energy and utility companies.

Question 2 and 2.1 from the purchaser questionnaire concern the classification of the purchasing process. The purchasers were asked about whether they know about the classification of operational, tactical, and strategic purchasing and view it as useful. Operational purchasing concerns all aspects of purchasing after an order has been placed (see Figure 6). Tactical purchasing involves all aspects of purchasing before an order has been placed (see Figure 6). Strategic purchasing involves all activities on management level that extent outside of purchased project level (see Figure 6). All of the purchasers knew about the classification of the purchasing process into operational, tactical, and strategic elements (see Table 7). But only 2 out of the 12 purchasers viewed the classification as practical (see Table 7). The main argument against the practicality was that in practice typically one purchaser covers all three aspects of purchasing and therefore the boundaries between the elements are fluid.

	Classification of purchasing tasks into operational, tactical, and strategic aspects:	
	known:	practical:
Interview 1	✔	✘
Interview 2	✔	✘
Interview 3	✔	✘
Interview 4	✔	✘
Interview 5	✔	✘
Interview 6	✔	✘
Interview 7	✔	✘
Interview 8	✔	✘
Interview 9	▨	▨
Interview 10	✔	✘
Interview 11	✔	✔
Interview 12	✔	✔
Interview 13	▨	▨
Interview 14	✔	✘

▨ = Question not applicable

Table 11: Classification of purchasing tasks into operational, tactical and strategic aspects

4.6. On average the interviewees rate their master data as good to satisfactory and the majority can conceive a standardization and are willing to share their master data

The last three questions 11, 11.1 and 11.2 were centered around master data quality, the willingness to share master data and the possibility of a standardization of master data.

First the interviewees were asked to rate the quality of their different types of master data in German school grades, with 1 being the best possible and 6 the worst possible (see Table 12). It should be noted that one of the interviewees (interviewee A) mentioned that service master data is not used at his company and therefore he could not give a grade for that particular type of master data. On average the participants graded their supplier master data as a 2.5. On average all interviewees graded the material master data with disposition data as a 2.4, their service master data as a 2.9 and finally the commodity group data as a 2.9.

Type of master data	Average Grade
Supplier master data:	2,5
Material master data with dispostion data:	2,4
Service master data*:	2,9
Commodity group data:	2,9

*based on 13 answers

Table 12: Average master data grades

Secondly the interviewees were asked whether they can imagine sharing their master data with their commercial partners. Out of the 14 interviewees 11 would be willing to share their master data with their commercial partners (see Table 13). It should be noted that 5 out of the 11, who were willing to share their master data, made it very clear to only be willing to share it under heavy data protection and in accordance with the latest data protection laws.

	Willingness to share master data:	
	Yes:	No:
Interview 1		✕
Interview 2	✓	
Interview 3	✓	
Interview 4	✓*	
Interview 5	✓*	
Interview 6	✓	
Interview 7	✓*	
Interview 8		✕
Interview 9	✓	
Interview 10	✓*	
Interview 11	✓	
Interview 12	✓	
Interview 13		✕
Interview 14	✓*	

*	= mentioned data security

Table 13: Willingness to share master data

Lastly the interviewees were asked whether they could imagine a general form of standardization for master data. Out of the 14 interviewees 12 could imagine a general form of standardization (see Table 14). The majority of the interviewees either mentioned using an existing form of standardization or using an equivalent to the EAN-Codes.

	Standardization of master data:	
	conceivable:	not conceivable:
Interviewee 1	✓	
Interviewee 2	✓	
Interviewee 3	✓	
Interviewee 4	✓	
Interviewee 5	✓	
Interviewee 6	✓	
Interviewee 7	✓	
Interviewee 8		✕
Interviewee 9	✓	
Interviewee 10	✓	
Interviewee 11		✕
Interviewee 12	✓	
Interviewee 13	✓	
Interviewee 14	✓	

Table 14: Standardization of master data

5. Discussion: Industry 4.0 will partly help with some of the current challenges in purchasing network construction, but it will also magnify some

In the previous section the results that were obtained from the interviews have been stated, in this section the obtained results and its implications will be discussed. The results of this study indicate that the interviewed network construction experts view IT Optimization, Process Optimization, Supplier Management and Change Management as their main focus areas. The 4 themes summarize the main answers given by the interviewees. Whereas IT Optimization and Process Optimization have a clear focus on challenges, Supplier Management and Change Management are focused on mitigating challenges which are likely to be caused by the introduction of new systems and technologies. Altogether the main focus lies on improving the interconnection with suppliers, the automation of minor purchases, dealing with suppliers, and managing the upcoming developments. Furthermore, the results have shown that in practice purchasing tasks are not separated into operational, tactical, and strategic elements, but rather purchasers supervise all elements within a given project or purchase. Moreover, this study has highlighted that there is an adequate level of master data quality, that the majority of the interviewees can imagine a form of standardization of master data, and would be willing to share their data, may it be under certain prerequisites. Generally, it can be stated that there is no pressing problem in purchasing network construction, but rather the wish for a controlled evolution.

Concerning IT Optimization, the challenges could be caused due to the unique peculiarities of network construction services and services in general (see Table 5). The variability of quality and high uncertainty present in network construction and services in general could be the root cause of problems in developing improved systems, as standardization is difficult and varying from company to company (see Table 5). Exemplary for the uncertainty in network construction, especially regarding soil conditions, was the statement from Interviewee 8: “within the cities (…) there are often times archaeological discoveries like city walls, that cancel any prior timelines”. These types of uncertainties are likely hard to account for within systems and software. Therefore, it is imperative to develop a general standardization of master data for network construction and maintain an adequate level of quality within the master data sets, as it was mentioned by Interviewee 5. Once the foundation for an implementation of Industry 4.0 technologies has been laid, Big Data analytics in conjunction with cloud capabilities and artificial intelligence are most likely to deliver the desired improvements from Industry 4.0 technologies. Through applying the aforementioned Industry 4.0 technologies it should be possible to create a software that scans the existing ERP-systems and other software regarding the currently needed steps to advance the process. It should be noted that a wide scale application of new technology and software in network construction will be a difficult process, due to the particularities of purchasing services and network construction services (see Table 4). These difficulties are likely to arise because services in general are complicated to standardize, due to their varying levels of quality. Therefore, the aforementioned development of data standardization is key. A first stage could be to inform the user of what task he needs to complete in what software (see Figure 9). The second stage could be that these steps are automated and checked through artificial intelligence (see Figure 9). The area of remote working is going to benefit of increased usage of cloud capabilities, because this allows for storing data independently of the given hardware, as long as an internet connection is present. Furthermore, cloud computing allows for making complicated calculations regardless of the given local hardware. These two factors are going to allow for even more location-independent work, possibly changing our day-to-day work lives as we know them. All in all, the area of IT Optimization is closely linked to Process Optimization as they are dependent on each other and one cannot be improved without adjusting the other.

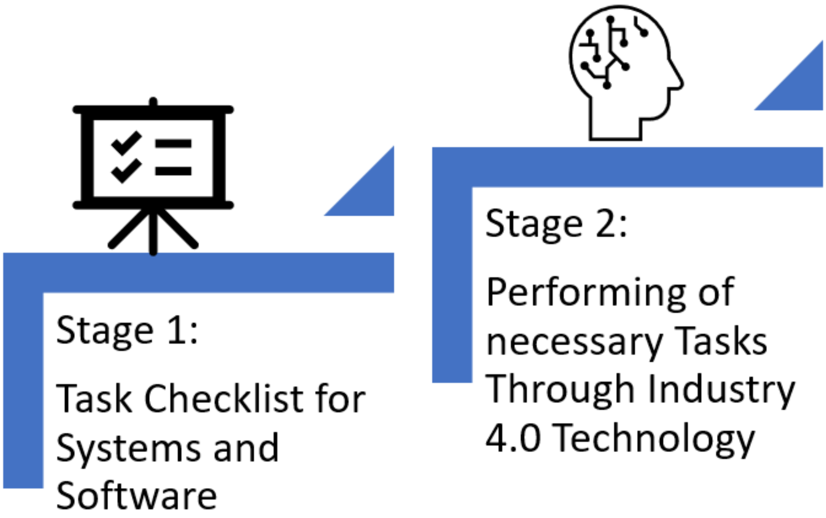

Figure 9: IT Optimization

Process Optimization centers around reducing internal and external interfaces and improve the process of making minor purchases. Also, in this case the special characteristics of network construction services are likely to be the cause of this optimization focus (see Table 5). Namely the high amount of uncertainty as well as the high complexity could cause the mentioned complex processes and difficulties in internal and external interfaces. Again, a general standardization of master data would be the foundation that would enable an introduction of Industry 4.0 technologies. The most appropriate Industry 4.0 technologies for these areas are cloud capabilities, Big Data and Artificial Intelligence. Through cloud capabilities the need for exchanging data files via email can be eliminated and both parties have excess to the same files and can update them in real time, this solution can also be used to eliminate internal interfaces during the specification phase. In a future step the entire process of exchanging data could be conducted by Artificial Intelligence working together with Big Data to provide the needed plans and files at the right time to the right persons. Moreover, the interviewees wish for an improvement of making minor purchases. This can also be achieved through the same Industry 4.0 technologies. Furthermore, the obtained data regarding a standardization of master data and the willingness to share master data with commercial partners provides a usable basis for such an implementation. A first stage could be the development of a central tendering platform that would mimic existing private platforms to a certain extent (see Figure 10), as it was mentioned by some of the interviewees. In order to be useable and feasible it would be appropriate to limit the regional scope of the tendering platform and work together with other utility companies and the relevant suppliers in order to have the necessary universal standards. By considering other utility companies in this solution suppliers would be compelled to adopt and take part in this platform. This tendering platform would make use of cloud capabilities in order to facilitate the data exchange, as well as artificial intelligence and Big Data to consider all relevant and qualified suppliers (see Figure 10). A second stage could be that the purchaser only enters the necessary parameters particular network construction, and the entire process would be conducted autonomously through Artificial Intelligence in conjunction with Big Data (see Figure 10). Artificial Intelligence would incorporate the most appropriate suppliers in the tender, on the basis of the Big Data analysis of previous tenders and their evaluation. The negotiation and commissioning of the supplier would also be conducted by an AI with using Big Data analysis as its foundation. However, all these developments need a certain technological basis to be implemented and this is where Supplier Management becomes important.

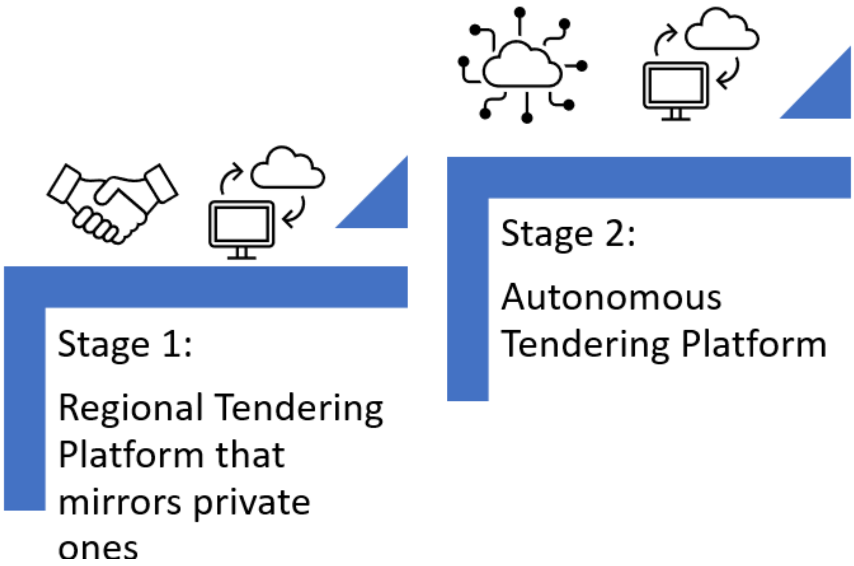

Figure 10: Process Optimization

The emerged theme of Supplier Management has shown that because of the scarcity of suppliers and their partly limited IT, knowledge suppliers need to be closely managed. The shortage of suppliers in turn could be fueled by the regionality of the network construction sector, where small contracts are not feasible for larger out of state contractors. Furthermore, the special characteristics of network construction (see Table 5) could also play a role, since network construction is a complex and highly specific area. The previous themes have shown that the interviewees view the connection with suppliers as an area where improvements would be beneficial. Moreover, the two previous themes rely heavily on Industry 4.0 solutions, yet they will not work, if suppliers do not have the willingness as well as the capabilities to use the offered technical solutions. In order to be able to implement Industry 4.0 elements in the purchasing of network construction, suppliers need to be educated and trained regarding the benefits and opportunities that arise through a greater interconnection with their customers. This is especially critical as some small suppliers already struggle with answering an email, may it be from the ERP-system or from a purchaser. Nonetheless, it should be noted that the two interviewed representatives of construction companies indicated that they possess the required technical capabilities, yet the compatibility with their client's systems is lacking. Moreover, this optimization differs in the regard from the previous two, that it cannot be improved through Industry 4.0, but rather that it is going to be exacerbated as more and more complex technical solutions are going to be introduced in purchasing over the coming years.

The last theme to be considered is Change Management. Whereas the previous theme of supplier Management has an external focus, Change Management has an internal focus and centers around how to manage the generational change and handle the introduction of new software and technologies. Managing change in network construction is likely to be a challenging task, since it is a highly complex matter that involves a high amount of uncertainty and is also rather complex (see Table 5). At its core, this theme is not problem focused, but rather an accompanying element of introducing Industry 4.0 technologies or new software. Like the previous theme, Industry 4.0 is not going to be offering improvements in this area, but rather negatively impact it. As it was mentioned by the interviews, some coworkers already question and inhibit the introduction and implementation of new technology and software. Although it can be beneficial to question novel ideas and development, the obtained data rather points towards a certain indifference regarding change to their existing processes and software. Over the coming years more and more novel programs and systems are likely to be developed and introduced throughout purchasing. Albeit these novelties are likely going to be specifically tailored for purchasing network construction, but they will offer benefits. These future developments will require careful management in order to take both experienced and young employees along and make both feel comfortable with the new developments.

One possible way to introduce change and take all internal stakeholders along is through setting up interdisciplinary teams, as one of the interviewees mentioned. There should be teams focusing on innovation and change management within purchasing as well as within the company. The first stage would be to set up interdisciplinary teams prior to the search and implementation of the desired change to discuss what is needed and being able to voice concerns (see Figure 11). Furthermore, prior to the implementation all purchasers and affected employees need to receive the appropriate training as well as the opportunity to provide feedback. The second stage takes place during and after the implementation of the desired change (see Figure 11). Purchasers need to be able to give feedback in regard to adjustments within the change, as well as being able to voice criticism. On the basis of the obtained feedback, adjustments should be made, and the feedback should be implemented. By implementing these stages all purchasers, no matter what their background is, feel involved and can positively impact change (see Figure 11). Industry 4.0 technologies in the form of cloud storage could also be used to facilitate the prior discussion and plans, as well as the review and feedback opportunities.

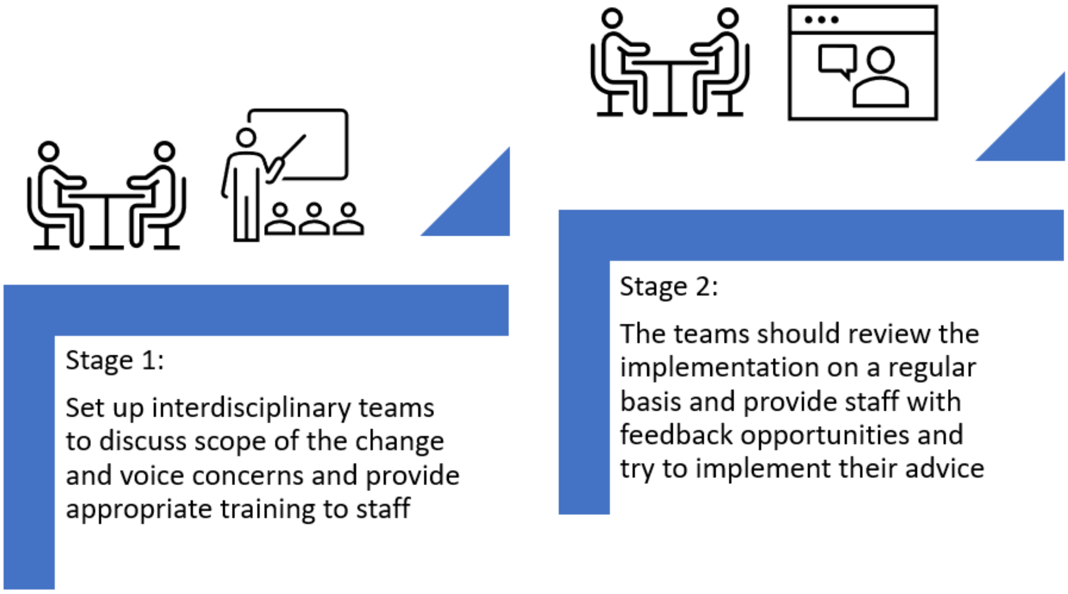

Figure 11: Change Management

When comparing the obtained results with the stated propositions two out of three propositions can be at least partially confirmed. Propositions 1 concerned the classification of the purchasing process. The results show that in practice the boundaries between the three classifications dislimn, although theoretically it is possible to separate them. Therefore, Proposition 1 has to be rejected. Proposition 2 concerned itself with linking Industry 4.0 solutions with a specific area of purchasing. As the results indicate, certain Industry 4.0 technologies are especially applicable in certain areas of purchasing, yet they are also tied to the specific challenges. Accordingly, Proposition 2 can be partly confirmed. Proposition 3 involved the centrality of (good quality) data. On the basis of the results, this can be confirmed.

Regarding the rejected classification of purchasing tasks, it should be noted that none of the interviewees work for a large enterprise, where such a classification could be useful and applicable. Nonetheless, the classification can still be useful when trying to develop and implement Industry 4.0 applications, because it allows for a clear overview of task groups. These groups then can be individually tested for their suitability for Industry 4.0 technologies, while conducting the others normally. This allows large scale changes without rewriting the entire purchasing process.

The master data results support the introduction of Industry 4.0 elements in purchasing. Through the willingness to share their master data, under data protection laws, interconnected Industry 4.0 solutions are a viable option. Interconnected solutions that include suppliers, ranging from a joint regional tendering platform to automizing elements of the purchasing process, all require data access and in turn access to master data. Furthermore, the results regarding a form of standardization are a further step in the direction of implementing Industry 4.0 solutions. Through proposing the usage of existing forms of standardization, such as EAN-Codes, the introduction or drafting of a standardization should be relatively easy. Although, such a standardization cannot be done without considering the supplier side and competitors, because otherwise it would be likely not wholeheartedly adopted by suppliers. All in all, the results show that the data foundation for a possible implementation of Industry 4.0 elements are present, but this basis has to be jointly developed and tested.

When associating the obtained themes with the proposed classification of purchasing it becomes obvious that the main affected areas of purchasing are operational and tactical purchasing. (see Figure 7). IT Optimization affects both operational and tactical purchasing as software and systems are essential in conducting the associated tasks in both areas. Process Optimization also affects both operational and tactical purchasing because both areas are made up of processes. Naturally, it could be argued that each optimization focus affects strategic purchasing as it steers the other two and would be responsible for implementing changes, but in this case only the directly affected areas of purchasing are concerned. Supplier Management affects all areas of purchasing, starting with tactical purchasing, where suitable suppliers are selected and the first contact is initiated, followed by operational purchasing, where every transaction with a supplier is concluded and evaluated, and lastly strategic purchasing, where the big picture of the supplier relationship is managed, and possible further measures are discussed. Change Management only affects strategic purchasing, since the strategic level is responsible for managing and introducing changes.

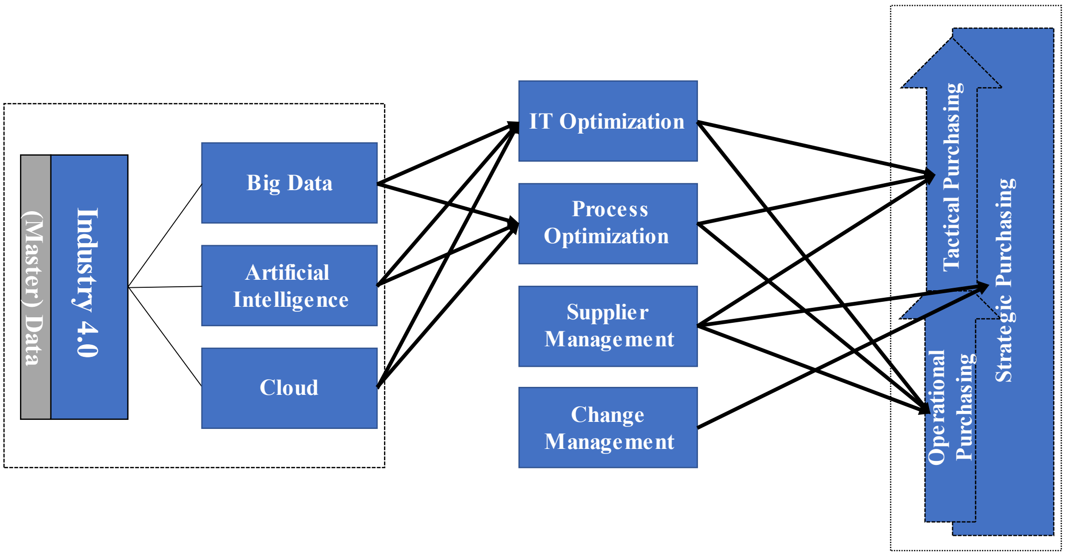

Figure 12: Results model

On the basis of these considerations areas where Industry 4.0 technologies are able to assist can be identified. Generally, it can be said that no revolutionary developments through Industry 4.0 can be expected in purchasing network construction in the near future, since the implementation of new systems and preparations is likely to take several years. Since purchasing network construction is essentially purchasing a (complex) service, it is not going to benefit as much from Industry 4.0 as materials purchasing. This is likely in part due to the unique characteristics of services, such as the difficulty of standardizing.

5.1. Conclusion: Industry 4.0 assistance in purchasing network construction is possible, but it will not bet revolutionary and will require tailored solutions

Finally comparing the developed research model with the obtained results highlights that the impact of Industry 4.0 is not as large as it was initially believed and as literature suggests. While in general Industry 4.0 is likely to have a significant impact on purchasing in general, the area of purchasing network construction is essentially the purchasing of a highly specialized service that is difficult to standardize. The main difficulties are likely caused by the unique peculiarities of (complex) services. Therefore, developing suitable systems for purchasing network construction is likely to be more difficult than a similar system for purchasing goods. This is aggravated by the fact that many smaller suppliers have a limited IT knowledge which complicates the communication and interaction with utility companies. This is reflected by the developed research model (see Figure 8), as it only focused on the positive aspects of Industry 4.0.

This research aimed to identify whether purchasers of network construction can be assisted with the help of Industry 4.0 classified into different levels of purchasing. On the basis of conducting qualitative interviews, it can be concluded that purchasers of network construction can be assisted through applying the Industry 4.0 technologies of: Big Data, Artificial Intelligence, and Cloud capabilities. The proposed Industry 4.0 solutions (see Figure 9, Figure 10, and Figure 11): assist with using multiple ERP-systems, conduct tenders for (minor) purchases, and help with facilitating change. The difficulty in implementing and developing Industry 4.0 solutions for purchasing network construction is in part due to the unique characteristics of purchasing services, e.g. difficulty of standardization and the high amount of uncertainty (see Table 4 & Table 5). The four themes show that the areas of optimizations within the purchasing of network construction are all interconnected and influence each other. While IT Optimization and Process Optimization can be improved by implementing Industry 4.0 technologies, Change and Supplier Management concern the challenges Industry 4.0 will aggravate. Finally, the results also indicate that Industry 4.0 will not only be beneficial, but also intensify already existing challenges.

It has been shown that the most pressing current challenges are within optimizing processes and IT. Specifically existing software solutions have to be simplified and made more user friendly, including improved user interfaces. Likewise, complex processes with an underlying simple focus need to be optimized and the process of making minor purchases need to be automated. Furthermore, the internal and external interconnection needs to be improved, especially the exchange of data, and the process of making minor purchases needs to be sped up and revised. This could be achieved in part by applying Cloud capabilities, Big Data and Artificial Intelligence (see Figure 9, Figure 10, and Figure 12). Moreover, the results from this study show that the quality of master data (see Table 12), conceivable forms of master data standardization (see Table 14) and the willingness to share them (see Table 13) provide a usable basis for introducing Industry 4.0 solutions, such as an automatic tendering platform. This suitable and useable data basis expands research by Raptis et al. (2019) who claim that data enables Industry 4.0 solutions. Therefore, some of the aforementioned challenges might be partially improved or solved through Industry 4.0 in the future.

The proposed classification into operational, tactical and strategic elements was deemed as not practical by the interviewees, since in practice purchasers usually conduct all tasks that are necessary for a given project. The classification of the purchasing process in operational, tactical, and strategic aspects may seem practical and useful in theory (van Weele, 2018), but this research has illustrated that in practice this is not the case. Nonetheless the classification could still provide a useful theoretical overview of the different elements within purchasing and can be used to develop further improvements through Industry 4.0 technologies by showing where tasks show similarities and can be comprised into a group.

Regarding the importance of master data, this research has shown that there is a willingness to share master data in interconnected systems and that a standardization of master data is conceivable. And that the general standardization should be based on existing standards and systems, such as EAN-Codes. Through these results, this study supports existing research from Nienke & Birkmeier, (2015), regarding the importance of data and adds that there is an adequate level of data quality present. Whereas Haug & Stentoft Arlbjørn (2011), claim that many companies face problems due to faulty master data, this study has shown that in general there is an adequate level of master data quality.

This research has also given a small insight into the world of network construction and its particular features (see Figure 7). While this is by no means a complete and exhaustive description and showcasing, it has shown the basic features, its wide range of uses and its complexity. Furthermore, this study has highlighted that even within purchasing services further distinctions have to be made and not only a differentiation between purchasing goods and purchasing services, but also a differentiation within purchasing services. Moreover, this research has shown the importance and uniqueness of network construction, especially since it remains unrepresented in existing literature and even the more general focus on complex services remains relatively ignored. In addition, this analysis has displayed that in the future companies in the utility sector will have to focus on how to manage the approaching change, as well as its existing smaller suppliers.

When assessing the overall results, they show that a broad application of Industry 4.0 within the purchasing of network construction is likely going to be difficult due to the difficulty of standardizing services and the unique characteristics of purchasing network construction. These findings hint towards that Industry 4.0 could be easier to implement in purchasing, where a high degree of standardization is present. Literature generally seems to have neglected the implementation of Industry 4.0 in service purchasing and the positive and negative effects of implementing Industry 4.0 in general. Additionally, existing literature mainly focuses on purchasing in manufacturing industries (e.g. Lehmacher, Betti, Beecher, Grotemeier, & Lorenzen, 2017, p. 3; Glas & Kleemann, 2016, p. 63), whereas this study has shown that purchasing network construction will need a tailored Industry 4.0 approach. These findings contribute to the existing literature by highlighting the need for research to focus on Industry 4.0's negative aspects. Moreover, the expected new types of collaboration caused by Industry 4.0 (Glas & Kleemann, 2016, p. 63) and several other benefits, may only be achievable within the purchasing of manufacturing companies without any extensive internal and external preparation.

This research also contributes to practice, as its shows managers what areas of their operation they have to pay attention to over the coming years, as well as where potential Industry 4.0 solutions could be beneficially applied. Purchasing managers will have to carefully manage their existing and potential small suppliers, as their IT related difficulties are likely only going to get worse. Specifically purchasing managers should try to increase the amount of digitalization present within their smaller suppliers in order to prepare them for the upcoming developments and keep them in their supplier portfolio. Additionally, purchasing managers also have to consider how they implement and manage change, in order to both address young and experienced employees. If experienced employees are taking part in the development process of the new systems and software their knowledge is saved and they are more acquainted with it. The proposed two stage process for change management (see Figure 11) can serve as a guideline or basis for actions. Nonetheless, this generational change cannot be underestimated as it could potentially harm day-to-day operations as well as the implementation of new elements. Interplaying with the change management is the wish for improved IT, here the managerial implications are clear, purchasing managers should focus on streamlining and improving their existing software solutions, possibly taking inspiration from private purchasing experiences. This optimization of IT and process interplays with the other identified area of optimization, namely supplier management. When the internal process and IT solution are optimized, optimizing external interfaces with suppliers can be based on the existing internal changes. The results indicate that in order to provide not only internal improvements smaller suppliers also need to be trained and prepared. Otherwise, the implementation of Industry 4.0 in utility companies will be limited to internal processes and the interaction with large suppliers that possess the necessary IT knowledge and capabilities. Furthermore, without developing and educating smaller suppliers within network construction, competition within tendering is going to be reduced and ultimately smaller suppliers may be squeezed out of the market. Additionally, this research has shown that in practice classifying purchasing tasks is not applicable as purchasers of network construction conduct all necessary tasks within their projects. Only when a company has reached a certain size purchasing managers should think about separating the individual purchasing process steps.

All in all, the insights into the purchasing of network construction this study has given, demonstrate that a general application of Industry 4.0 technologies within purchasing is not easily feasible. But if the appropriate internal and external foundations for the implementation of Industry 4.0 solutions have been laid, purchasers of network construction and construction companies could profit immensely from shorter administrative times, as well as reduced operational activities. Additionally, special care should be taken that the knowledge of experienced employees is implemented in the newly developed systems. The key foundation is to take along all internal stakeholders during this, as well as developing the supplier side. Moreover, the conducted research has highlighted that literature and practice should pay close attention to the negative ramifications Industry 4.0 will bring about and which existing challenges it will intensify.

5.2. Limitations and future research: Future studies should focus on what potential negative aspects Industry 4.0 will bring about and how to counter them

After conducting this research certain limiting factors have to be considered. When looking at this study it has to be noted that it was being conducted during the corona virus pandemic and therefore, certain aspects, such as the emphasis on remote working may have been seen as more important under the given circumstances by the interviewees.

Regarding future research the focus of Industry 4.0 centered research should not only concentrate on potential benefits, but also include the challenges and negative aspects it will intensify and create. Among them are how to ensure that older and experienced purchasers or employees carry and support the changes and how to keep smaller companies as potential suppliers, even though their IT capabilities may be lacking. Particularly future research should analyze how experienced employees can be convinced of supporting new systems and technologies and how their knowledge can be kept within in the company. Possibly this could be achieved by incorporating the experienced employees and their knowledge in the development of new systems and software. Yet this incorporation needs to be researched, especially how they could be incorporated and in what way. Furthermore, the existing supplier base and its technical capabilities should be studied, in order to be able to adequately support and develop them.

Additionally, further research should be conducted in the field of data. Namely what kind of standardization should be employed, how the data is protected in accordance with regulations, and what geographical scope regarding the standardization should be used. Furthermore, exact data quality standards have to be developed, which companies have to meet in order to take part in any kind of standardization and Industry 4.0 software implementation.

Moreover, research should broaden its existing Industry 4.0 spectrum and also focus on potential applications within service purchasing and especially complex services, such as network construction. Especially the difficulty of standardizing (complex) services should be examined further and how this influences the developing and introduction of Industry 4.0 in service purchasing. In general, future research should shift its focus from mainly studying manufacturing companies and also consider service-oriented companies.

Additionally, future research should be conducted in the field of network construction, as the current literature basis is virtually non-existent. Specifically, it should be examined what specific and unique peculiarities network construction possesses and how these factors affect the purchasing of it. Yet this study can be seen as a starting point for future research in this area.

Finally, the results of this research should be broadened, by conducting quantitative studies to examine whether the presented results are quantifiable and can be generally applicable. Moreover, quantitative studies should focus on whether there are differences between regions or countries, specifically regarding the identified challenges and the capabilities of the suppliers.

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Appendix A1: Interview Questions (English and German):

Interview Questions (English):

Background:

1. What position do you have at the company?

   1.1. What are your activity emphases?

2. Literature refers to operational, tactical, and strategic purchasing as (…).
   Have you heard of this division?

   2.1. Does this division make sense to you, from your practical point of view?

Problem in general:

3. Where in your day-to-day tasks do you wish for optimizations?

   3.1. Where are these optimizations needed the most?

Problem solving and problem prevention:

4. How do you handle the cases today, where you would need the aforementioned optimizations?

5. What could help you with preventing the need for optimization from the get-go?

Industry 4.0:

6. What do you understand by the term Industry 4.0?

7. Do you currently use Industry 4.0 elements, like i.e. real-time communication, intelligent systems, horizontal and vertical (digital) networking, during your daily work?

   7.1. If so, at what stage in the purchasing process?

8. Could you imagine that Industry 4.0 will bring about the aforementioned optimizations? If so, how?

9. Can you imagine optimizations for your day-to-day tasks on the basis of Industry 4.0? If so, what kind of optimizations?

   9.1. Do you imagine that Industry 4.0 will change your job and if so how?

10. Imagine one realistic and one ideal scenario of Industry 4.0 in purchasing. What would each individual scenario look like? Please elaborate your thoughts.

    10.1. Scenario 1 (realistic):

    10.2. Scenario 2 (ideal):

11. Within the scope of implementing Industry 4.0 in purchasing the availability of good quality data will be crucial. This brings about a number of challenges, among them the quality of the different master data and the lack of standardization of the data.

    How do you rate your master data quality (using school grades from 1-6)?

    - ☐ Supplier master data:
    - ☐ Material master data with disposition data:
    - ☐ Service master data:
    - ☐ Commodity group data:

    11.1. Can you imagine sharing your master data with your commercial partners?

    11.2. Can you imagine a general form of standardizing master data? If so, how could this be achieved?

Interviewfragen (Deutsch):

Hintergrund:

1. Welche Position haben Sie im Unternehmen?

    1.1. Was sind Ihre Tätigkeitsschwerpunkte?

2. Die Literatur versteht unter operativem, taktischem und strategischem Einkauf (…). Ist Ihnen diese Unterteilung bekannt?

    2.1. Erscheint Ihnen aus praktischer Sicht diese Einteilung sinnvoll?

Problem Allgemein:

3. An welchen Stellen Ihrer täglichen Arbeit wünschen sie sich Optimierungen? (in Bezug auf Einkauf)

    3.1. An welcher Stelle sind die Optimierungen am dringendsten?

Problemlösung und Problemprävention:

4. Wie gehen Sie heute mit den Fällen um, in denen Sie sich Optimierungen wünschen?

5. Was würde Ihnen dabei helfen, sodass Optimierungen von vornherein nicht nötig wären?

Industrie 4.0:

6. Was verstehen Sie unter dem Begriff „Industrie 4.0"?

7. Benutzen Sie aktuell Industrie-4.0-Elemente, wie z.B. Echtzeitkommunikation, intelligente Systeme, horizontale und vertikale (digitale) Vernetzung, im Rahmen Ihrer täglichen Arbeit?

    7.1. Wenn ja, an welcher Stelle im Einkaufsprozess?

8. Können Sie sich vorstellen, dass Industrie 4.0 die vorher genannten Optimierungswünsche mit sich bringt? Wenn ja, in welcher Form?

9. Können Sie sich - auf Basis der Industrie 4.0 Technologien - weitere Optimierungen für Ihre tägliche Arbeit vorstellen? Wenn ja, was für welche und an welcher Stelle im Einkaufsprozess?

   9.1. Können Sie sich vorstellen, dass Industrie 4.0 Ihren Beruf verändern wird? Wenn ja, in welcher Weise?

10. Stellen Sie sich ein realistisches und ein idealtypisches Industrie-4.0-im-Einkauf-Szenario vor. Wie würden diese jeweils aussehen, und wann glauben Sie, würden diese Szenarien eintreten? Bitte erläutern Sie Ihre Gedankengänge.

    10.1. Szenario 1 (realistisch):

    10.2. Szenario 2 (ideal):

11. Im Rahmen der Implementierung von Industrie 4.0 im Einkauf wird es auf die Verfügbarkeit von verschiedensten Daten in guter Qualität ankommen. Diese Voraussetzung bringt einige Herausforderungen mit sich, unter anderem die Qualität der verschiedenen Stammdaten und die fehlende Standardisierung dieser Daten.

    Wie beurteilen Sie Ihre Stammdatenqualität (in Schulnoten von 1 - 6)?

    - ☐ Lieferantenstammdaten:
    - ☐ Materialstammdaten mit Dispositionsdaten:
    - ☐ Leistungsstammdaten:
    - ☐ Warengruppendaten:

    11.1. Können Sie sich vorstellen, Ihre Stammdaten mit Ihren Marktpartnern in Zukunft zu teilen?

    11.2. Können Sie sich eine allgemeine Standardisierung der Stammdaten vorstellen? Wenn ja, wie könnte diese aussehen?

Appendix A2: Interview Questions for Construction Companies (English and German)

Interview Questions (English):

Background:

1. What position do you have at the company?

    1.1. What are your activity emphases?

Problem in general:

2. Where in dealings with utility companies do you wish for optimizations?

    2.1. Where are these optimizations needed the most?

Problem solving and problem prevention:

3. How do you handle the cases today, where you would need the aforementioned optimizations?

4. What could help you with preventing the need for optimization from the get-go?

Industry 4.0:

5. What do you understand by the term Industry 4.0?

6. Do you currently use Industry 4.0 elements, like i.e. real-time communication, intelligent systems, horizontal and vertical (digital) networking, during your daily work?

7. Could you imagine that Industry 4.0 will bring about the aforementioned optimizations? If so, how?

8. Within the scope of implementing Industry 4.0 in purchasing the availability of good quality data will be crucial. This brings about a number of challenges, among them the quality of the different master data and the lack of standardization of the data.

How do you rate your master data quality (using school grades from 1-6)?

- ☐ Material master data with disposition data:
- ☐ Service master data:
- ☐ Commodity group data:

8.1. Can you imagine sharing your master data with your commercial partners?

8.2. Can you imagine a general form of standardizing master data? If so, how could this be achieved?

Interviewfragen (Deutsch):

Hintergrund:

1. Welche Position haben Sie im Unternehmen?

1.1. Was sind Ihre Tätigkeitsschwerpunkte?

Problem Allgemein:

2. An welchen Stellen Ihrer täglichen Arbeit wünschen sie sich Optimierungen (in Bezug auf Kontakt mit Energieversorgern im Rahmen von Netzbauprojekten)?

2.1. An welcher Stelle sind die Optimierungen am dringendsten?

Problemlösung und Problemprävention:

3. Wie gehen Sie heute mit den Fällen um, in denen Sie sich Optimierungen wünschen?

4. Was würde Ihnen dabei helfen, sodass Optimierungen von vornherein nicht nötig wären?

Industrie 4.0:

5. Was verstehen Sie unter dem Begriff „Industrie 4.0“?

6. Benutzen Sie aktuell Industrie-4.0-Elemente, wie z.B. Echtzeitkommunikation, intelligente Systeme, horizontale und vertikale (digitale) Vernetzung, im Rahmen Ihrer täglichen Arbeit?

7. Können Sie sich vorstellen, dass Industrie 4.0 die vorher genannten Optimierungswünsche mit sich bringt? Wenn ja, in welcher Form?

8. Im Rahmen der Implementierung von Industrie 4.0 im Einkauf wird es auf die Verfügbarkeit von verschiedensten Daten in guter Qualität ankommen. Diese Voraussetzung bringt einige Herausforderungen mit sich, unter anderem die Qualität der verschiedenen Stammdaten und die fehlende Standardisierung dieser Daten.

   Wie beurteilen Sie Ihre Stammdatenqualität (in Schulnoten von 1 - 6)?

   - ☐ Materialstammdaten mit Dispositionsdaten:
   - ☐ Leistungsstammdaten:
   - ☐ Warengruppendaten:

   8.1. Können Sie sich vorstellen, Ihre Stammdaten mit Ihren Marktpartnern in Zukunft zu teilen?

   8.2. Können Sie sich eine allgemeine Standardisierung der Stammdaten vorstellen? Wenn ja, wie könnte diese aussehen?

Appendix A3: Additional Graphics

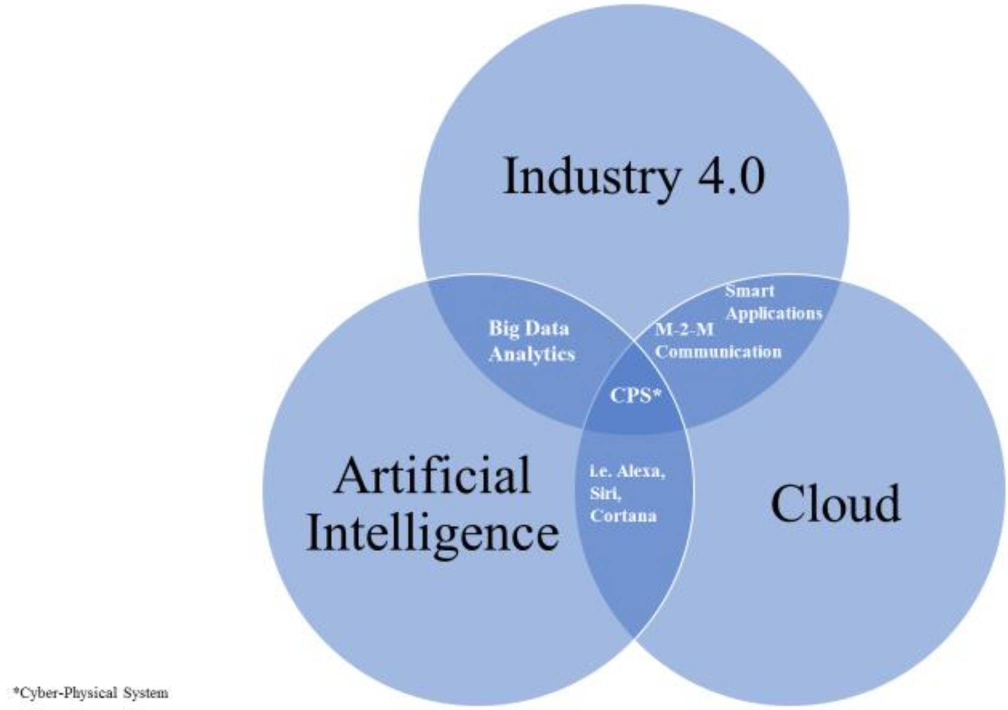

Figure 13: Relationship between Industry 4.0, AI and the Cloud

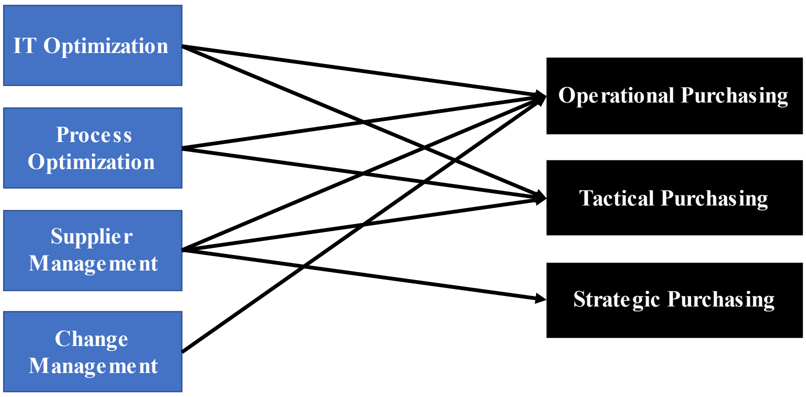

Figure 14: Allocation of themes to area of purchasing

Appendix A4: Interview Transcripts

The interview transcripts are classified.