Analysis of the current state of Industry 4.0 in purchasing: A multiple case study based on the purchasing year cycle

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ABSTRACT,

The much-discussed topic, Industry 4.0 receives more and more attention. However, literature mainly focuses on Industry 4.0 in coherence with production and the practical application. Due to the minimal attention in literature for purchasing in connection with the fourth industrial revolution, this research pursues the subject. A multiple case study has been conducted with companies from different industries to explore the status quo of applications regarding Industry 4.0 technologies in procurement. The theoretical framework of the purchasing year cycle was adapted regarding Industry 4.0 and used to analyse the interviews. Qualitative data obtained from nine conducted interviews was analysed and compared with corresponding literature. The analysis revealed that Industry 4.0 in procurement is still in its infancy. Most companies market new technological developments within their firm as Industry 4.0 applications. However, some of the implementations can be considered as advanced technologies of the third industrial revolution and not as Industry 4.0 in procurement. Therefore, companies need to fully adapt the third industrial revolution before being able to successfully carry on with the fourth industrial revolution. It was figured that the companies share similar visions. They aspire to make use of Industry 4.0 applications to lead the firm to more transparency, efficiency, and enable more precise forecasting. It was analysed that interconnected cyber-physical systems can be considered as the organisational antecedents for Industry 4.0 in procurement. Following the adapted framework could help companies to overcome uncertainties that appear due to the novelty of the topic. Hence, the concept of a company-wide interconnected ERP system received special attention in this paper. The ERP system is suggested as a unifying system for the companies encouraging the connection to their suppliers.

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Keywords

Industry 4.0 in procurement, purchasing year cycle, category sourcing cycle, fourth industrial revolution, cyber-physical systems, supplier integration.

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1. INDUSTRY 4.0 IN PROCUREMENT: A CASE STUDY IN EIGHT DIFFERENT COMPANIES

Since the 1990s, purchasing has been recognised as one of the main drivers to successfully compete in today's environment and to contribute to a company's success (Ellram & Carr, 1994, p. 11; Pearson & Gritzmacher, 1990, p. 91). Watts et al. (as cited in Ellram & Carr, 1994, p. 12) recognised that an improved buyer-seller relation can benefit the corporate strategy. Since then, purchasing has received a lot of recognition from different scholars and industrialists. Special attention attracted the currently much-discussed topic *Industry 4.0*, which is also known as *Industrial Internet* in the United States, *the fourth industrial revolution*, *smart manufacturing* or *integrated industry* (Evans & Annunziata, 2012, p. 4; Schmidt et al., 2015). It is described by literature that Industry 4.0 is initiated by the Internet which allows communication between humans as well as machines through large networks (Brettel et al., 2014, p. 37), appearing in various forms. Those forms can be cyber-physical systems, Internet of Things, cloud robotics, 3D printing, sensor technology, big data (Batran et al., 2017, p. 15), artificial intelligence, autonomous vehicles, nanotechnology, biotechnology, materials science, energy storage, and quantum computing (Schwab, 2015, p. 1). However, a clear definition of Industry 4.0 that is largely accepted does not yet exist (Bauer et al., 2014, p. 18; Hofmann & Rüsch, 2017, p. 33). Industry 4.0, such as all previous industrial revolutions, can only be considered as a revolution if it affects the entire value chain and if elementary changes in the production system have been accomplished (Schiele, 2016, p. 16). Since industrial revolutions led to different improvements such as efficiency, flexibility, quality, productivity, economic growth (Rüßmann et al., 2015, p. 1) and enhanced overall performance (Lee et al., 2014, p. 3; Schwab, 2015, p. 2), it is important for firms to appertain to the early adopters in order to acquire a competitive advantage and outperform its competitors (Schrauf & Berttram, 2016, p. 31). In order to understand procurement activities, the *purchasing year cycle* (Schiele, in press, pp. 12-21) is used and adapted for the application of Industry 4.0. The framework is based on planning and reflecting a company's overall strategy and acting in coherence with its suppliers.

The aim of this research is to discover new opportunities for Industry 4.0 in purchasing. The research's findings are combined with the adjusted purchasing year cycle and the outcome of nine conducted interviews. The overall goal is to develop a research that is applicable and relevant to different industries. Previous findings from the literature will be confirmed and new findings will be added to the existing literature. Due to the novelty of the topic, businesses might struggle in the application of technologies that can be considered as part of Industry 4.0. Practical recommendations for future implications regarding the category sourcing cycle in coherence with Industry 4.0 will be given. The study's goals lead to the following two research questions:

Which Industry 4.0 technologies are implemented in the procurement department?

How does the purchasing year cycle contribute to supplier integration?

This thesis will outlines by the following structure: after a first Industry 4.0. focused analysis of the purchasing year cycle, research design and methodology are introduced to evaluate the research questions. Results based on the nine interviews are presented and synthesised in relation with the purchasing year cycle. Lastly, recommendations towards practical implementations and future research are made based on synthesised literature and interview findings.

2. THEORETICAL BACKROUND TO THE INDUSRTIAL REVOLUTION AND THE ADAPTED PURCHASING YEAR CYCLE REGARDING INDUSTRY 4.0

2.1 Historical foundation of the four industrial revolutions: a shift from technologies to the Internet as trigger of the industrial progress

2.1.1 In the first industrial revolution, the steam engine led to social changes

The first industrial revolution found its origins in Great Britain in the late 18th - and the early 19th century and can be described as a radical innovation that was strongly related to economic change (Bruland & Smith, 2013, p. 1716). Flooding appeared in the late 17th century and restrained the quarrying in British mines (Merton, 1938, pp. 506-509). Thomas Savery developed the first engine, trying to solve the flooding problem in coal mines (Frenken & Nuvolari, 2004, p. 420). Later, Newcome developed a steam engine becoming in active usage in 1712 (Spear, 2008, p. 54). Watt's adjusted Newcomen's engine and received a patent in 1769 to protect his invention (VACCARI, 2005, p. 491). The new developed steam engine was at first installed in a coal mine in 1776 (Spear, 2008). Watt's engine was more efficient in use of fuel while Newcomen's engine had a cost advantage in purchase (Frenken & Nuvolari, 2004, p. 422). Watt's engine was especially demanded in areas without coal deposits while Newcomen's engine was highly requested in coal mining regions (Frenken & Nuvolari, 2004, p. 422). In the end, Watt's invention was not exclusively used for coal mining but also for other industries such as the textile segment. The different forms of usage led to social changes which were related to the increasing amount of work capacity and the steam power that made the movement of people more flexible (Schiele, 2016, p. 15).

2.1.2 The electric motor and the assembly line led to the second industrial revolution

The second industrial revolution lasted from the late 19th until the early 20th century and was driven by education and pragmatic knowledge regarding natural phenomena. Scientific knowledge combined with technologies resulted in major breakthroughs (Mokyr, 1998, p. 1) such as the production of low-priced steel (Mokyr, 1998, p. 3) that created the opportunity to build large ships (Mokyr, 1998, p. 7), and the invention of the automobile (Mokyr, 1998, p. 8). The electric motor and the coherently developed assembly line were the critical factors driving the second industrial revolution (Schwab, 2015, p. 1) resulting in the division of labour and newly designed factory plants. In general, social changes and technological breakthroughs appeared during the second industrial revolution. Compared to the first industrial revolution, the second one did not only primarily affect Great Britain but the entire Western hemisphere (Mokyr, 1998, p. 14); leading to new economic and social standards.

2.1.3 Logic controllers paved the way for the third industrial revolution

The third industrial revolution, also known under the name digital or computer revolution, started in the 1970s with the introduction of programmable logic controllers (Brettel et al.,

2014, p. 37; Schwab, 2015, p. 1). Continuous learning effects conduced to adapt change and new innovations (Greenwood, 1997, p. 6). It is notable that capacities of computers continue to increase drastically to become part of other products such as cameras, stereos, and cars (Jensen, 1993, p. 15). Yet, income inequality between skilled end less skilled workers increased within the third industrial revolution (Greenwood, 1997, p. 4).

2.1.4 The Internet is the trigger of Industry 4.0

It is expected that the fourth industrial revolution will build on the third by adding network technologies. These network technologies enable benefits in the field of machine-to-machine communication, predictive maintenance, product engagement and client interaction (Bloem et al., 2014, p. 7). In order to understand Industry 4.0, it is important to catch the difference between the third and fourth industrial revolution. The major distinction between the earlier industrial revolutions and the fourth industrial revolution will be the trigger by the continuous development of the Internet; unlike previous ones, where radical technical innovations contributed to the industrial progress (Brettel et al., 2014, p. 37). Industry 4.0 enables companies to digitalise the entire value chain, improve the overall quality, decrease the time to the market, and develop new business models (Hermann et al., 2016, p. 3928; Oesterreich & Teuteberg, 2016, p. 122).

Industry 4.0 is correlated with technological innovations and improvements. Hence, suppliers become increasingly important for firms to deploy their potential and to achieve a competitive advantage (Luzzini & Ronchi, 2011, p. 14). Single firms cannot be seen as isolated units that compete against each other but rather as agile and flexible networks (Edquist, 1997, p. 2). The procurement department is particularly important because it connects the firm with its suppliers, which is further evaluated in the following segment.

2.2 The basis for the study is the purchasing year cycle's subset: the category sourcing cycle

The purchasing year cycle reflects the company's overall strategy and its strategic alignment with suppliers. The purchasing year cycle (*Figure 1*) consists of two different circuits, the *category sourcing cycle* and the *purchasing department cycle* (Schiele, in press, p. 14). Both cycles are repeated on an annual basis. The purchasing department cycle focuses on activities regarding the entire purchasing department, while the category sourcing cycle is executed on a category level (Schiele, in press, p. 13). The focus of the study is the category sourcing cycle in coherence with Industry 4.0. The category sourcing cycle is divided into six different levels that occur in succession: demand identification and planning, category strategy, supplier identification and selection, negotiation and contracting, executing, and supplier evaluation.

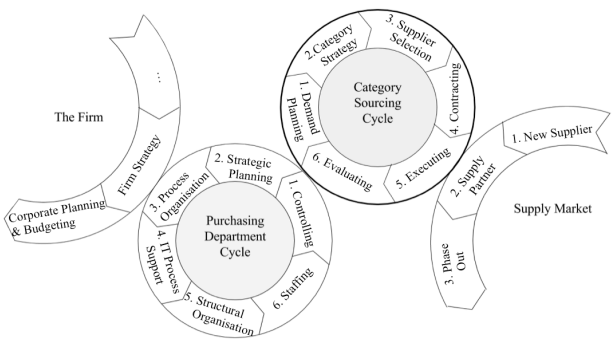

Figure 1: Purchasing year cycle (Schiele, in press, p. 14)

2.3 Exemplification of the category sourcing cycle levels and adaption of Industry 4.0

The procurement personnel carries out the category sourcing activities on a commodity level. Correspondingly, the procurement department's management holistically executes the purchasing year cycle (Schiele, in press, p. 13). The different categories of the category sourcing cycle and the resulting opportunities for Industry 4.0 are outlined below. First of all, the traditional perspective of the category sourcing cycle is explained. The following section evaluates the opportunities and changes that come along with Industry 4.0.

2.3.1 Demand identification and planning: the ERP system is extended with the CPFR tool and more data becomes available in the purchasing spend cube

Demand identification and planning level refer to expected quantities that are required from suppliers (Schiele, in press, p. 16). For that matter, companies use historical data in order to traditionally plan the required demand. One of the tools that utilises data based on historical evaluations is the *purchasing spend cube* (Schiele, in press, p. 16). The purchasing spend cube can be viewed from three different angles: purchasing spend per supplier, per spend category, and per internal budget holder (Van Weele, 2009, p. 15). A uniform IT infrastructure is required to fill the spend cube and to provide purchasing expenditure in detail. Part of the IT infrastructure and thus the spend cube is an *Enterprise Resource Planning system* (ERP) (Schiele, in press, p. 16). The ERP system integrates and simplifies different business processes such as material management and finance (Schiele, in press, p. 16). When smart technologies are introduced, an interconnection between the different departments and company's suppliers as well as customers is enabled (Ramanathan, 2017, pp. 26-27). These technologies facilitate firms to make short-term and long-term forecasting and planning (Ramanathan, 2017, p. 43).

In order to apply a web-based *Collaborative Planning, Forecasting and Replenishment* (CPFR) tool (Fliedner, 2003, p. 14), a sophisticated connection between the buying firm and the supplier needs to be established. Trust is the crucial element to share real-time data. A CPFR tool can be additionally applied to an ERP system in order to enhance the integration with suppliers. A CPFR tool fills the purchasing spend cube by providing improved data and more information about the supplier and the relationship. Companies operating in 'smart-planning' environments make use of real-time data. It improves the flow of materials as well as information (Ramanathan, 2017, pp. 26-27). By applying a CPFR tool, the ERP system is further developed and more data becomes available in the purchasing spend cube.

2.3.2 Category strategy: introduction of a new framework that helps firms to adapt radical changes coming from Industry 4.0

The category strategy component defines a strategy for each one of the sourcing categories and a corporate budget plan is designed in response to the different strategies (Schiele, in press, p. 16). Arnold (1997, as cited in Schiele, in press, p. 16) defined seven points in order to explain the category sourcing strategy. These seven points are the value creation model (1), the sourcing object (2), the supply chain model (3), the amount of suppliers (4), the locational concept (5), the pooling concept (6), and the lever selection that might be additionally added (7). However, these seven points of category sourcing strategies are

changed to a different framework due to the disruptiveness of innovation within Industry 4.0.

2.3.2.1 The strategy and procurement 4.0 framework enables an easier adaption of new technologies

The new *strategy and procurement 4.0 framework*, which is suggested by Weissbarth et al. (2016, pp. 5-10), helps firms to adapt to the radical changes that are associated with new opportunities of Industry 4.0. The framework substantially focuses on the digital supply chain. Thereby, the changing competitive landscape is recognised as one of the main drivers in today's business environment. Competition and technological developments are included in the framework while Arnold's framework (1997, as cited in Schiele, in press, p. 16) concentrates on the traditional sourcing categories. The changing landscape and competition are not taken into consideration and seems to be less focused on organisation's disruptive changes due to new technologies. The introduced strategy and procurement 4.0 framework encompasses six points: the new procurement value proposition (1), digital category and service procurement (2), digital supply chain and supplier management (3), innovative procurement data utilization (4), digital processes and tools (5), and organization and capabilities (6) (Weissbarth et al., 2016, pp. 4-5). The different points of the strategy and the procurement framework are outlined in detail in the following sections.

New procurement value proposition (1) refers to increasingly blurred supply chains. New business models are created through opportunities that come along with the introduction of new technologies (Weissbarth et al., 2016, p. 5). The data can be used internally to "better manage transportation flows, inventories, warehouse requirements, quality inspections, and other parts of the supply chain" (Weissbarth et al., 2016, p. 7). However, suppliers can benefit from the data by adjusting their products and processes according to the buyer's needs. Digital category and service procurement (2) are related to new opportunities but also new issues that will arise. Two of these opportunities are the internal connection and transparency in the purchasing department and within the overall company. This can be achieved by implementing sensors to capture, analyse, and act upon real-time data. Actions are immediately carried out and suppliers are given access to the real-time data. However, certain issues will occur concerning the ownership of the data that is collected by sensors and used by the end consumers (Weissbarth et al., 2016, p. 7). Literature suggests that based on the current development in different industries, digital supply chain and supplier management (3) will shift from big enterprise resource planning (ERP) providers to more specialised partners (Weissbarth et al., 2016, p. 8). Those specialised companies enable an integration of suppliers, customers, distributors, and captive production by providing real-time data (Weissbarth et al., 2016, p. 8). The availability of real-time data gives buyers access to up-to-date ratings of suppliers such as ratings that evaluate the risk associated with suppliers and judge a supplier's performance. Hence, efficiency can be improved while at the same time costs are reduced and the customer's experience is enhanced. Innovative procurement data utilisation (4) is, "probably the most important enabler for Procurement 4.0"(Weissbarth et al., 2016, p. 8). Real-time data offers more precise forecasts for upcoming market trends and allows understanding customers, markets, and suppliers much better. Data analysis will help to optimise maintenance services and the availability of replacement parts (Weissbarth et al., 2016, p. 8). By using more precise forecasting, uncontrollable losses of production caused by machine stops or breakdowns can be prevented (Bounazef et al., 2014, p. 65). Digital processes and tools (5) help to improve the entire supply chain in areas such as negotiation and delivery and increase the cooperation between different firms and departments (Weissbarth et al., 2016, p. 9). Digitalisation and automation enhance the level of efficiency, resulting in a decrease of running expenses. Digitalisation fosters organisations and capabilities (6) to be 'rethought' and changed over time. The entire organisational structure has to be aligned in order to succeed in the transformation to a digitalised company (Weissbarth et al., 2016, pp. 9-10).

2.3.3 Supplier identification and selection: trust increases the suppliers' commitment and attitude

After ascertaining the demand, the best possible supplier needs to be identified and selected. The request for quotation (RFQ) or the request for proposal (RFP) provide specific information about potential suppliers (Spencer, 2002, p. 1). These processes are able to automatically respond and analyse the supplier's given information (Spencer, 2002, p. 1). Next to the tools for supplier selection, auxiliary devices for supplier selection can be emphasised. According to Schiele (in press, p. 17), "two tools may be highlighted: preferred supplier lists and global sourcing". Preferred supplier lists refer to suppliers that stand out due to their former performance. Therefore, they have antecedent access to an RFQ or RFP document (Schiele, in press, p. 17). The second tool, "global sourcing refers to the identification and possible contracting of suppliers located in other countries than the buying company" (Schiele, in press, p. 18).

However, the entire procedure is time-consuming and involves a lot of human capacity in order to make the RFQs and RFPs comparable. Instead, a digitalised supply chain and purchasing department are fully responsive and notify purchasers in near-real-time in order to adjust demand requests (Schrauf & Berttram, 2016, p. 14). Different scenarios can be immediately evaluated and compared with a platform and an optimal solution is shared with the supplier (Schrauf & Berttram, 2016, p. 14). This procedure allows the purchaser to take over a rather strategic position than to pursue an operative task (Schrauf & Berttram, 2016, pp. 14-15). However, trust contributes positively to the supplier's engagement. This results in an overall positive attitude towards the partnering company (De Ruyter et al., 2001, p. 282). Suppliers that add value to the buyer's product can contribute to an advantage for the buying firm in the operating market segment (Wilson, 1995, p. 4). Suppliers become seemingly more important since supply chains become more competitive (Luzzini et al., 2015, p. 109).

2.3.4 Negotiation and contracting: virtual reality training, bitcoin, and blockchains as enabler for Industry 4.0

Next, negotiations about the exact conditions take place to find a common agreement between two or more parties (Schiele, in press, p. 18). The outcome of such a negotiation is highly dependent on the skills, preparation and persuasion knowledge of the two actors (Holmes et al., 2017, p. 81). The final result of a negotiation is, for example, a legally binding contract that accounts for a year.

It is suggested by literature that *virtual reality-assisted* negotiation training helps to positively influence the negotiation ability and conversation skills (Broekens et al., 2012, p. 1). The training is based on a role play interaction between a real life person and a virtual agent that is able to express emotions and explain its behaviour (Broekens et al., 2012, p. 2). Alternatively, a virtual person and a tutor reflect and conduct a

review of the negotiator's performance (Core et al., 2006, p. 686). The training can lead to a better negotiation outcome, yet it does not necessarily need to result in a better outcome (Broekens et al., 2012, p. 10). Analytics enable the negotiator to be best prepared and to get all the necessary information to follow a category strategy (Batran et al., 2017, p. 134). Apps can be used to update the agent with the latest data last minute before the negotiation (Batran et al., 2017, p. 134).

Technologies that are part of Industry 4.0 create solutions that can be immediately shared with, for instance, suppliers and partners (Schrauf & Berttram, 2016, p. 14). Bitcoin and Blockchain belong to those technologies that bear unveiling potential to revolutionise the traditional way of contracting (Peters & Panayi, 2016, p. 2). Bitcoin and Blockchain cryptographically secure the networks that can be regarded as an enabling tool for smart contracting by leaving out intermediary institutions (English et al., 2016, p. 3; Guadamuz & Marsden, 2015, p. 3). Therefore, blockchain technologies become more powerful because they leverage the majority of parties that are dishonest, undermine corruption, maintain fairness and bargains can take place securely, without high transaction and legal costs (Asharov et al., 2015, p. 1; Bentov & Kumaresan, 2014, p. 1; Cleve, 1986, p. 364; Kosba et al., 2016, p. 1). Blockchain technology allows processes to be transparent. It builds the basis for smart contracts, which have the potential to redesign contract law, without human intervention (Peters & Panayi, 2016, p. 2). Smart contracts are digital programs that autonomously execute contract clauses based on certain binding conditions (Fairfield, 2014, p. 38; Zhang et al., 2016, p. 270). With the help of connected systems, contracts can be transferred into the ERP system, which will give buyers the opportunity to search for a specific contract in a central database (Batran et al., 2017, p. 132). Having a homogeneous system within the entire company will increase efficiency and production.

2.3.5 Executing: giving suppliers access to the ERP system

When negotiations took place and a mutually agreed contract is signed, final orders can be placed (Schiele, in press, p. 19). Nowadays, machines place orders automatically and the purchase order is transacted by extensive IT systems. Those systems accede the payment process and provide a life cycle perspective on the contracted goods and on the supplier (Batran et al., 2017, p. 132).

The ERP system automatically transfers the required delivery to the suppliers and allows them to add information regarding the consignment and the product. By giving suppliers restricted access to the ERP, system they are able to get information about consumers' behaviour and improve their product to that effect.

2.3.6 Supplier evaluation: different programmes enable access to real-time data and lead to more transparency within the company

Lastly, the performance of the supplier will be evaluated. The assessment can take place in form of a qualitative or quantitative analysis. Qualitative assessments refer to, for example, the delivery reliability and evaluate reasons for potential problems. Quantitative supplier evaluation comes directly from the ERP system and does not provide the purchaser with information about potential problems (Schiele, in press, p. 20). However, at the demand identification and planning level, the ERP system is extended with the CPFR tool.

There are various different programs that support the selection process of suppliers such as *technique for order preference by similarities to ideal solution* (TOPSIS), *analytical hierarchical process* (AHP), *fuzzy analytical hierarchical process* (FAHP), *analytic network process* (ANP) and many more (Sultana et al., 2016, p. 62). These process tools can be used as integrations between two systems; integrated systems are more commonly used than single systems (Sultana et al., 2016, p. 62). The integrated system is preferred because of its flexibility, ease of use, and measurements (Sultana et al., 2016, p. 62). AHP weights the different criteria such as quality or delivery out of which FAHP creates an order preference and TOPSIS finds the closest answer to an ideal solution (Sultana et al., 2016, pp. 60-63). ANP and the TOPSIS are widely used regarding the supplier selection. The ANP model weights the different supplier criteria in order to transfer the criteria into numeric values that can be used by TOPSIS to select the most suitable solution (Sultana et al., 2016, p. 61). Additionally, for quantitative analysis, the *multi-objective linear programming* (MOLP) is an adequate tool. The different methods will enable buyers to have access to the real-time performance evaluation of the suppliers (Batran et al., 2017, p. 132) that is added to the overall image and can be used for negotiations and contracts.

2.4 The adapted category sourcing cycle is the foundation for a more transparent collaboration between buyers and suppliers

Different groups of purchased items are part of *the supply market* (*Figure 1*). It is not based on, for example, product characteristics but rather constitutes various suppliers offering substitutable products (Schiele, in press, pp. 14-15). The usage of a company-wide ERP system will increase the company's transparency. Buyers will be able to simply search for information about suppliers in the enterprise's system, learn what contracts are already in existence, how the supplier is evaluated and find potential alternatives (Batran et al., 2017, p. 132). However, suppliers seemingly interact more with the buying firms and become more integrated into their systems (Luzzini et al., 2015, p. 109). Nowadays, purchasing activities are highly automated and give suppliers access to information such as the current inventory, which allows purchasers to focus on more strategic tasks.

3. METHODOLOGY: LITERATURE RESEARCH IN CORRESPONDENCE WITH NINE CONDUCTED INTERVIEWS

The research aims to identify which Industry 4.0 technologies are implemented in the procurement department and how the purchasing year cycle contributes to supplier's integration concerning the fourth industrial revolution. The study is a qualitative research that includes semi-structured interviews (*Appendix A1*). Interviews were conducted to evaluate and to understand the overall context (Eriksson & Kovalainen, 2015, p. 5). Literature is used to further develop the purchasing year cycle in coherence with Industry 4.0 and to explain the relevance of involving suppliers in the processes of digitalisation. Knowledge and ideas about the subject have been established and were provided prior to the interviews to approach different viewpoints about this topic (Myers, 2013, p. 5).

Medium to large companies were selected as interview partners that have an employee range from 16,000 to 625,000. The data collection is based on one questionnaire, including ten interview questions. Two out of nine interviews were held in person and the other seven on the phone. The interviews were conducted with eight different companies. Two of these companies gave their concession to record the interview while the other

participants preferred not to be recorded due to the confidentiality of the topic. All of the interviews were carried out with employees from companies spread over different industries. First, the respondents were asked about the suppliers' integration in procurement in general. Following this, they were asked questions regarding the Industry 4.0 implementations and the suppliers' involvement in those processes. The next interview sections focussed on the future expectations of Industry 4.0 and the interconnection between the departments regarding digitalisation. The interviewees can be described as experts due to their extensive knowledge in the field of digitalisation in procurement and the implementation of new projects.

4. ANALYSIS AND RESULTS: INTERVIEWS WITH RESPONDENTS FROM EIGHT DIFFERENT COMPANIES

4.1 The results are structured according to the interviews' outline

In total, nine interviews were conducted with employees specialised in procurement and digitalisation, a full version of the interviews can be found in *Appendix A2*. The results are arranged according to the questionnaire's outline (*Appendix A1*). Following a short introduction about the company and the participant, the supplier involvement in regular projects and Industry 4.0 activities are classified. The respondents outlined their expectations and visions regarding Industry 4.0 in their company. Ultimately, the role of procurement related to Industry 4.0 compared with other departments is evaluated An overview of the scope of Industry 4.0 applications based on the analysis of the interviews can be found in *Table 1* below. The provided table is based on analysis and does not necessarily capture the perception of the interviewees. Company G and Web Services are not included in the table due to the fact that they are seen as enablers regarding Industry 4.0 and cannot be classified as producing companies.

4.2 Company A: a firm that highly integrates suppliers and envisions a global supply network

Two to three times each year, meetings with suppliers take place in order to address issues but also to find solutions and to make suggestions for improvements. Mr R says that the suppliers are actively included in projects to get additional input and ideas from outside of the company and to elaborate on solutions. Developments towards the availability of real-time data are already in progress within the firm.

4.2.1 Blockchain and connective cars are approached by Company A in the next few years

Current projects deal with data accessibility, data evaluation, and scenario analysis based on production data, which is transferred to the supplier, for instance, in collaboration with a robotics provider. Projects that appear in the future could be in coherence with predictive maintenance, whereby data would be used from different divisions such as the paint shop and the pressing plant. Additionally, the available data could be used to measure the actual motion of production systems. This could be accumulated with production data to find out if, for example, an over specification exists. The information would be passed on to the supplier for a premium in order to improve their next generation of tools and to reduce over-specifications.

Projects that will be conducted in the next two to three years are related to connective cars. The procurement department could, for instance, initiate that sensors are placed at the antishock that measures the range of spring and the spring actions. The information is directed to the associated supplier with insights into customer's behaviour that might vary to the result of the test block. This could enable Company A to explore new business models with the use of connected and collaborating technologies.

Another topic that is aimed to be addressed in the future is related to blockchain along global supply streams. A global enterprise such as Company A has to fulfil and to document transport regulations. It is expected that new technologies enable the integration of all suppliers, the digitalisation of freight documents and an increase of the overall transparency.

4.2.2 Company A's vision is to revolutionise the traditional supply chain develop a global supply network

It is expected that real-time data availability throughout the value chain enables an error-free manufacturing without fearing bottlenecks. This includes reciprocally sharing information with the suppliers. The availability of real-time data can be help to become more transparent, making more accurate forecasts and to be able to react faster in a case of malfunctions. However, scenarios predict that the overall complexity increases. Tasks and competences of the procurement personnel shift from one-to-one relations with suppliers to data science, strategic thinking and understanding of networks. This shift can only be successful if the employees see the big picture and stop being blinkered. This way of thinking can be encouraged by enabling departments to work on different topics together and having one common goal, e.g. making information and data more transparent.

Company A's vision for procurement is to revolutionise the traditional supply chain and to transform it into a digital network. It is expected that changes not only appear within the company but rather within the entire network. Appearing problems ought to be discussed with a holistic view in order to

Questions	**Companies**					
	Company A	Company B	Company C	Company D	Company E	Company F
1) I.4.0 processes in daily business	X	X	X	✓	X	X
2) I.4.0 processes in procurement	✓	✓	X	✓	X	✓
3) I.4.0 pilot projects in procurement	✓	✓	✓	✓	X	X
4) I.4.0 projects standing in line	✓	✓	X	✓	✓	✓

Table 1: Overview – Scope of Industry 4.0 applications based on the analysis of the interviews

revolutionise the existing supply chain structure. With this vision in mind, projects are started in which current and new suppliers are involved.

4.2.3 Purchasing department is leader and driver of Industry 4.0

The procurement department can be considered as more advanced in their way of thinking as well as in implementing projects that are carried out. Yet, also different departments are closely connected with each other. The procurement department can be defined as a driver of Industry 4.0 and has a big influence on the suppliers' development regarding new technologies. The buyer initiates the next steps to partner with suppliers and starts joint projects. Thereby, the purchaser's main task is to ensure a connection from the company to the supplier. In the future, data gained from this cooperation is made available to other departments such as the production.

4.3 Company B's main concern is to make the entire value chain more transparent to avoid forecasting issues

Company B's suppliers are highly integrated into daily business operations as well as in operations regarding Industry 4.0. Processes based on Industry 4.0 technologies are already implemented in the company's day-to-day business such as cameras that document the current inventory. The respondent, Mr S stated that suppliers have access to the camera pictures and automatically deliver new goods in case of scarcity. The Company B develops new innovations together with their suppliers, which are exchanged mainly on a platform.

4.3.1 Projects aim to avoid issues that appeared during the financial crisis

Documents regarding planning and construction are automatically provided to the suppliers since customers mainly request tailored solutions. The data flow from the Company B to the suppliers is already well developed, however, projects are tested to return the data flow from the suppliers back to the company. A pilot project that deals with the topic is the so-called 'safe room'. Technical expectations are communicated to the supplier. Different suppliers can individually fill the safe room. The safe room allows Company B to communicate for example the exact space for the headlamp housing, the connections, conductions, and screws etc. for automotive OEMs. Suppliers are then able to produce the specific parts by having exact specifications and visuals. In the next step, the supplier develops the searchlights and transfers the data regarding the new construction into the platform offered by Company B.

Further pilot projects are in planning regarding the inter-connected demand mapping. Projects that stand in line to be tested are aiming for more transparency within the company and intent to clearly communicating the firm's needs. The project's main objective is to avoid issues that appeared during the financial crisis such as the accordion effect. At that time, Company B lowered its production. Due to depleted demand and oversaturated inventory in the warehouse, Company B' suppliers reduced the production as well. This phenomenon appeared along the value chain. However, the economy recovered faster than expected and more raw materials and goods were required. This led to a supply shortage and concomitant losses. The pilot project in planning makes the company and the value chain more transparent. By doing so, every party along the supply chain is able to react homogenously on appearing trends and changes.

4.3.2 The purchasing department lags behind, due to their dependency on suppliers

Company B expects that Industry 4.0 reduces failure costs, lowers the level of bureaucracy, and makes processes within the company more efficient. The procurement department at Company B lags behind other departments regarding the development of Industry 4.0 because of their dependency on the suppliers.

Next to collaborations with suppliers, Company B internally established a network, which enables different departments to exchange ideas, to work closely together and to exchange proceedings regarding different projects. In general, the procurement department at the Company B has potential to improve their abilities in terms of Industry 4.0 and digitalization.

4.4 Company C focuses on horizontal integration

Company C is working on platforms in order to foster the exchange of information and to digitalise operative procurement. Suppliers have limited access to the platform; being solely restricted to the ordering process. However, the platform is not yet comprehensively applied. Key suppliers that are part of the development of innovations are more involved than others in some contexts.

4.4.1 Quantitative forecast to make the value chain more transparent

Most companies have an ERP system that collects data. However, the quality of the data is often insufficient and, for instance, information needed for negotiations might not be available. In the end, only the result of the negotiation becomes available in the ERP system.

At the moment, Company C's purchasing department concentrates on price forecasting. However, information gathering approaches the method of how to systematically collect information and how to analyse and it. It is seen as a necessity to accomplish more precise forecasting. Specifically addressing price forecasting, there are many products that do not have an official market price since they are specialised for the chemistry market. Company C sees new opportunities in data mining that helps to objectively identify price forecasts and is able to recognise patterns. According to Mr U, data mining will significantly improve the collection of data, the recognition of patterns, and enables better price forecasting and development. A better analysis regarding the available data is expected to contribute to the purchasers understanding of the information. Correlated with this analysis, negotiations can be brought to a better completion.

An extensive logistics project at Company C in the United States was established in order to see the status of the product and its location. To realise the project, the purchasing department and the supply chain department worked closely together. The platform allows to better monitor partners, as well as second- and third-tier suppliers. The platform makes it possible to check whether the suppliers are respecting Company C's conditions or not.

A project in planning and testing, the horizontal integration, is to faster transfer information by making the entire value chain more transparent such as in quantitative forecasts. Big Data is used to make predictions and to show trends, for example, regarding the usage of raw materials. Within the value chain, a final buyer, an OEM, knows how many cars it plans to produce. The OEM puts the purchase order into a system, which informs

the suppliers, in this case, Company C, about how many components are needed. Suppliers transfer the number of components for the final production to subcontractors. With the help of an IT system, real-time information is passed along and made available within the entire supply chain. The real-time information can be transferred within Company C and used for different aspects, such as the commodity procurement or inventory holding. Availability of real-time data ensures planning security within the entire value chain.

4.4.2 Algorithms could lead to more fairness in negotiations and the entire value chain

Mr T expects that Industry 4.0 makes Company C become more transparent and fosters the integration within Company C and the relationship with their suppliers. He suggests that digitalisation will help to optimise the safety stock and reduce lead-times.

In the long term, strategic and operative tasks will be taken over by algorithms, which could lead to more fairness in the value chain, for instance, in negotiations. The outcome of the negotiation is dependent on the respective situation of the negotiator. When algorithms negotiate the price, a win-win situation could arise for the entire value chain.

4.4.3 Think tanks and own initiatives regarding Industry 4.0

The company has a specific team dealing with the topic Industry 4.0 that can be considered as a think tank. The information is available for every subsidiary. Every dimension is able to take on further initiatives regarding Industry 4.0 such as Mr T at Company C.

4.5 Company D sees the purchasing department in a leading position

Mr V explained that suppliers are integrated into regular innovation processes in procurement in order to systematically improve and implement new ideas.

4.5.1 Industry 4.0 to make procurement analysis more reliable

The Company D and its suppliers already adapted processes that are based on Industry 4.0 technologies such as an extensive logistics system. The Company D owns lorries and invests in additional vehicles to get along with the extensive transportations within the holding and to their clients. All lorries are provided with a tablet PC that is connected to a company-wide system. The drivers constantly communicate with the company in order to make transportation more efficiently and to plan sufficiently. Employees within the commissioning, for example, know exactly when the next lorry is coming and wait prepared to load the vehicle. Company D's purchasing department has implemented a web-based business intelligence tool that is connected to the firm's suppliers. All goods at the Company D are transported with standardised loading devices. During the summer, Easter, and the festive seasons more devices are needed than during the rest of the year. A web-based business intelligence tool automatically informs suppliers about the current inventory and sets an alarm when they have to deliver loading-devices.

Another pilot project stands in line to be tested. A predictive analytics tool is developed together with the Fraunhofer Institut Deutschland. It is based on cloud computing in order to make more accurate analysis by using public data, data from social media, customer's information as well as the company's data. The results are analysed and can be used in the company's different departments. The predictive analytics tool enables the holding to increase the degree of automation and digitalisation.

4.5.2 The purchasing department has a leading position within the company in Industry 4.0

The respondent expects that Industry 4.0 increases the overall transparency and efficiency in the company with tools such as predictive analytics. The company's vision is to build a network in order to use capacity efficiently by, for example, cooperating with competitors to bail out the capacity of the storage room of a lorry. At the Company D, the different departments are at similar levels of Industry 4.0 integration. However, the supply chain and the purchasing department have a leading position within the company regarding Industry 4.0.

4.6 Company E is about to start new pilot projects

According to Mr W, suppliers have access to a digitalised catalogue of standardised products. Authorised suppliers have admission to a web application for auctions with the focus on alloying elements.

4.6.1 Introduction of a new platform to foster supplier integration

To the current state, Company E has implemented an ERP system in procurement, which checks invoices and automatically pays them if they meet the standard form. For about ten years, the company uses a catalogue system to order office equipment and raw materials without involving the purchasing department directly. The delivery is directly brought to the user without directly involving the purchasing department.

Furthermore, Company E is going to implement a new platform for the purchasing department. All data that is involved in the ordering process, as well as documents, will be available in an IT system. Suppliers will have access to the IT platform; it will notify them when new orders are made. The platform is currently not intended to be interconnected with other departments and does not involve suppliers in the planning process. However, suppliers can fully integrate the new IT system, which is also used by other companies in the industry. The decision to what extent an implementation is made lies within the supplying firm. The new IT system fosters the integration and relation with the suppliers. Company E's suppliers diverse from large to small sized firms; naturally, not all suppliers have the same resources and are at the same level regarding digitalisation. The IT platform is the first pilot project at Company E for Industry 4.0 in procurement. The first tests will be run in July and August before finalising the first steps in September 2017. If the tests for the project are successful, all other subsidiaries will implement the new IT system in their procurement department.

Another pilot project, including three pre-selected suppliers, will be tested in a steel plant this August. Arriving goods will be equipped with a QR code in order to automatically fulfil a validity check of the product. Later, the project is intended to be enlarged within this specific steel plant and with respect to all delivering suppliers.

4.6.2 The purchasing department is internally seen as pioneer regarding Industry 4.0

Mr W explained that the steel industry will not be as digitalised as for example the automotive industry. Within the steel industry, component changes and improvements are made during the production process. This procedure makes it less

predictable compared to the automotive industry where all components of a car are known. However, digitalisation and Industry 4.0 will help Company E's departments to work closer together. The sales and distribution department is more advanced in the field of Industry 4.0 than the procurement department due to their close relationship with the automotive industry and their constant pressure to adapt to changes and new technologies. However, the procurement department is driven by innovations and new opportunities and they see themselves as pioneers regarding internal digitalisation within the company.

4.7 Company F's suppliers are partially involved in Industry 4.0 processes

The company's suppliers are completely integrated in daily processes and specific innovation processes in procurement. However, suppliers are not as much involved in tasks and projects that belong to Industry 4.0.

4.7.1 A supplier selection platform should contribute to the procurement strategy

Company F has an ERP system integrated within the entire company that stores data from the entire course of business. The suppliers are connected to ERP to get more information and instructions about their assignments. In addition, a warehouse system is implemented in the procurement department that stores data about suppliers and helps to evaluate them. The outcome is forwarded to the supplier in order to help them improve their performance in crucial points. Additionally, a platform that enhances the supplier appraisement stands in line to be tested. The platform aspires to register suppliers and make reclamations. Criteria in terms of supplier selection will be upgraded and touch-points increase. Furthermore, the platform should contribute to procurement strategies, monitors the supplier's development, fosters supplier integration, and optimises the integration between the different departments.

4.7.2 All departments have the same extent of knowledge regarding Industry 4.0

Company F's vision is to optimise networking, forecasting, and reactions in case of potential risks. Analysing data becomes easier with the help of Industry 4.0 technologies and integration between different departments is expedited. All departments are at the same level. They exchange knowledge about digitalization to optimise integration. The entire company is asked to participate when it comes to Industry 4.0 and every department has an equal role within the firm.

4.8 Company G and Company H as enabler for Industry 4.0

A classic department structure with different departments does not exist in such a way as in a producing company. Therefore, both companies are seen as enablers for producing firms to adapt solutions.

Mr Y explained that the suppliers are highly involved in, for example, demand planning and inventory planning. Suppliers are informed about campaigns to coordinate their warehouse capacity. They are informed when the delivery will take place. The warehouse capacity is usually not sufficient, for example, during Christmas. Key suppliers are asked to deliver at certain times regarding specific fixed dates to optimise processes. Suppliers have access to a platform that informs them about a number of products sold and how much inventory is still in stock. The company uses QR codes to include every supplier and article in its portfolio.

4.8.1 An EU-wide network for automated procurement is aspired

The procurement process itself is highly automated and is solely left to machine-to-machine communication when the procurement department of a supplier is digitalised. However, machine-to-machine communication is dependent on the supplier's development. An EU-wide network in which procurement is entirely automated stands in line to be tested. The new network will increase the overall efficiency and extend the customer's purchasing portfolio. As mentioned by Mr Z, digitalisation enables companies to become more transparent and make it easier to communicate and interact between different departments but also with suppliers and customers. To the current state, Industry 4.0 must be seen as connectional opportunity between different units.

4.8.2 Algorithms as enabler for finding the best product

Mr Y sees learning algorithms as an enabler to make decisions. Company G' vision is that within 5 to 10 years, processes are entirely based on machines and algorithms. Learning algorithms are capable of finding the best suitable product out of more than 100 million products. Mr Z from Company H expects that new business models appear such as to rent machine usage and not the machine itself.

According to Mr Z, companies usually start with Industry 4.0 applications in areas that are not directly affected by the core business to minimise risk. After first conducted tests regarding digitalisation, smart technologies are included in the main business. In the majority of cases, first, one person for each department is assigned with the task to approach Industry 4.0. When the implementations become more important to the company's core business, the entire team deals with the topic.

4.9 Companies mutually agree on transparency as major vision

Most interviewees agree on the same vision regarding Industry 4.0. They expect their companies to become more transparent, efficient, and automated by using technologies that belong to the fourth industrial revolution. More precise forecasting and optimised networking are awaited to positively contribute to firms overall performance. The different organisations mainly invest in platforms that enable a better connection and network with suppliers. Additionally, pilot projects regarding predictive analytics and different forecasting methods are tested or stand in line to be executed.

5. DISCUSSION: FINDINGS FROM PRACTICE DISCUSSED WITH THE ADAPTED CATEGORY SOURCING CYCLE

5.1 New contributions to the category sourcing cycle based on literature and interviews

In this study, the ERP system is recognised as the centre of the adapted category sourcing cycle, which enables the storage and reception of data. An extended framework is developed that outlines the importance of a connective system as seen below in *Figure 2*. Furthermore, the Enterprise Resource Planning tool is the unifying element that enables interconnectivity between departments. Operations that call for cooperation between different departments can be easier executed.

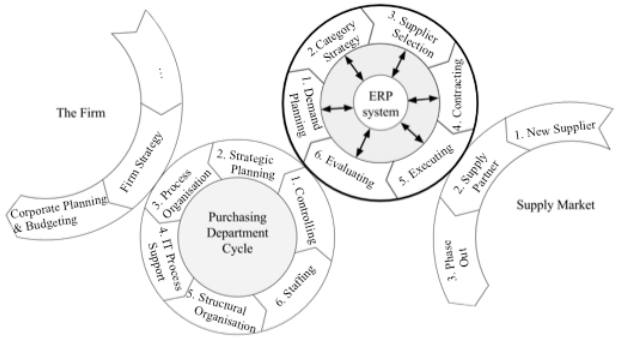

Figure 2: Adapted purchasing year cycle (own elaboration)

5.1.1 ERP systems require more detailed and holistic information resulting in the need for further development in demand planning

Starting with demand planning, an ERP tool can be used in combination with a Collaborative Planning, Forecasting and Replenishment system in order to bring together information from the side of the supplier and the buyer. The CPFR system acts on a strategic level and fosters integration between the buying and supplying firm, resulting in a stronger supply chain (Simmonds, 2016, p. 79). In a smart planning environment, downstream buyers place real-time data or orders to make it available to suppliers (Ramanathan, 2017, p. 27). Especially, in environments where planning is difficult, an intense integration and information exchange with the help of a CPFR tool is required (Ramanathan, 2017, p. 42).

According to Mr U from Company C, most companies already make use of an ERP system. However, the quality of the data is often insufficient or not available. This means in particular, how negotiations take place and how they are prepared. In the end, only the result of the negotiation becomes available in the ERP system. Old ideas such as forecasting are interpreted from a new perspective, for example, at Company D. Data from different sources and different areas are used to draw a more complex and accurate picture. Further projects regarding interconnected demand planning at the Company B are standing in line to be tested. These projects aim to make the supply chain more transparent in order to solve problems that appeared during the last financial crisis in 2008.

5.1.2 Category strategy: an improved procurement data utilisation is still rather a vision than reality

Information such as the corporate budget plan is made available within the system in order to increase the transparency to make company-wide check ups possible and information accessible (Weissbarth et al., 2016, p. 5). However, it turned out during the interviews that supply chains are not yet transparent but that it is rather a vision the companies strive for. Firms initiate pilot projects with this vision in mind. The Company A aims to create a digital network with their suppliers. Some firms already have a platform implemented or in planning that enables suppliers to see when they need to deliver new industrial goods (Company E). It was evaluated that the interviewed companies partially adapted an improved procurement framework, similar to Weissbarth et al. (2016, p. 8), but none of them has yet a complete data utilisation. It is suggested by literature that the entire organisational structure needs to be adjusted regarding Industry 4.0 (Weissbarth et al., 2016, p. 9). However, this is a complicated endeavour, especially in large companies such as Company A. Employees need to be stimulated in order to see the big picture and adapt to the companies changing needs. An extensive ERP system could help to reduce the complexity within the organisation and resolve communication barriers.

5.1.3 Supplier identification and selection: the relationship between buyers and suppliers increases in importance

Suppliers are traditionally identified by an RFQ or RFP. Preferred suppliers receive an RFP document earlier than their competitors (Schiele, in press, p. 17). This leads to a more deepening relationship between the buying firm and the supplier. It is especially important for OEMs to have a good connection with their suppliers in order to ensure reliable deliveries. Suppliers that are closely located to the production plants gain in importance. This is the case because of diminishing storage capacity and the continuous trend of just in time production (REF), which fosters companies to expand real-time data and instant communication with their suppliers.

Furthermore, selected suppliers can be integrated into the ERP system to a certain extent in order to foster communication. Good relationships between buyers and suppliers become more relevant since supply chains become increasingly important for a firms success (Luzzini et al., 2015, p. 109). Company B, for example, offers suppliers a safe room where they are informed about certain details and have free space to develop the product.

5.1.4 Smart ways of negotiating and contracting are not yet perceived

People from different divisions should be able to easily check whether a contract is in place with an existing supplier or not. Contracts could be stored in the ERP system and information about a specific contract could be looked up by using a search function (Batran et al., 2017, p. 132).

Mr U from Company C pointed out that data collection regarding negotiations rarely exist. None of the interviewees mentioned projects regarding smart contracting and how to include those in a company-wide ERP system.

5.1.5 Smart execution is in the planning process

When orders are executed, documents, such as delivery forms, could be made available in the ERP system in order to track the contract goods. Smart execution prevents the transit of goods by being able to trace back the purchased items. Traceability enables an exact accounting of supplier and reduces losses. Mr R, from Company A, says that he can imagine that blockchain could be used along the global supply streams to better comprehend transport regulations and document them.

5.1.6 Supplier evaluation: evaluation platforms contribute to the procurement strategy

Real-time supplier performance evaluations, as well as forecasts, will be available in a database. Thereby, data is provided in relation to the supplier's performance regarding the buying company as well as from external sources from the Internet. Different tools such as ANP and TOPSIS can be used to evaluate and rank the performance of different suppliers. Company F, for instance, is about to test a platform that registers suppliers, makes reclamations and evaluates suppliers based on various criteria. The platform positively contributes to the procurement strategies and to monitor the supplier's development.

5.2 Companies are shifting from the third industrial revolution to Industry 4.0

The adapted category sourcing cycle gives an outlook regarding opportunities; how the future in purchasing could look like.

When analysing the interviews it turns out that companies majorly test different Industry 4.0 applications. But have not yet fully arrived in in the fourth industrial revolution. Even though technologies already exist, it usually takes between five and ten years (O'Leary, 2008, p. 20) until a technology is implemented in major companies. Firms such as Company G and Company H offer solutions to make first implementations and switch to a rather digitalised company. Literature indicates that there is no commonly agreed definition regarding Industry 4.0 (Bauer et al., 2014, p. 18; Hofmann & Rüsch, 2017, p. 33). Most companies talk about Industry 4.0 and want to belong to the early adopters. However, it is not expected that a big bang appears but rather that Industry 4.0 is implemented in small evolutionary steps (Hofmann & Rüsch, 2017, p. 23). So far, literature has mainly focused on Industry 4.0 in production and not on procurement aspects. Therefore, not much evidence is allocatable about the status quo of the fourth Industrial revolution in purchasing. This is reflected in the amount companies spend on research projects in Industry 4.0 (Welke, 2015, p. 5). Leading research projects are in the production while projects in procurement leg far behind (Bischoff et al., 2015, p. 33).

6. CONCLUSION: A COMPLETE ADAPTION REGARDING INDUSTRY 4.0 IN PROCUREMENT HAS NOT YET EVOLVED

6.1 Transition between the third and fourth industrial revolution is marked as Industry 4.0

The study examines the current status of Industry 4.0 in procurement within different industries, primarily in Germany. Since no exact definition regarding Industry 4.0 exists, each company has to decide what it means for their purpose and how they can best apply it in the specific business context. The overall focus, so far, is to optimise processes and not to radically innovate them. New steps are steadily implemented and can be described as advancements of technologies of the third industrial revolution and not as a fully applied fourth industrial revolution. Companies market this development as Industry 4.0; yet, implementation of Industry 4.0 cannot be considered as an accomplished fact across the different German industries. Companies need to timely adapt technologies that belong to Industry 4.0 in order to keep up with global competition and achieve a competitive advantage.

6.2 Answering the first research question: connectivity fostering tools are the most applied implementations of Industry 4.0

RQ: Which Industry 4.0 technologies are implemented in the procurement department?

So far, the respondents' firms have mainly introduced or are about to implement platforms that enable faster communication and exchange with suppliers and help to evaluate their performance. Furthermore, projects are in planning that encourage connectivity (Company B) and help to make forecasts more precisely (Company D). Data mining was mentioned as particularly important to create and to become aware of new opportunities (Company C and Company A). Company G and Company H can be seen as enablers for other companies to stimulate transparency and connectivity within the companies and with their suppliers. Company G offers a B2B platform that connects multiple suppliers with buyers. Company H is a cloud-computing provider that supplies different services and features and allows companies to make first steps regarding Industry 4.0.

6.3 Answering the second research question: the adapted purchasing year cycle positively contributes to supplier integration

RQ: How does the purchasing year cycle contribute to supplier integration?

The adapted purchasing year cycle includes a well-developed ERP system in its centre that positively contributes to supplier integration. The ERP system increases a company's transparency and connects departments with each other. Suppliers can have access to certain parts of the IT system, which fosters the exchange of real-time data. The system also enhances the communication between both parties. The entire value chain can benefit from the implementation of ERP systems. Not only the first tier supplier knows the current inventory but the second tier supplier as well. Moreover, the second tier supplier can adjust orders due to the fact that real-time information about the up-to-date stock data is available from the buyer and the first tier supplier. This model works reciprocally along the entire value chain with an ERP tool as unifying element.

6.4 Practical and theoretical implications: more attention needs to be drawn on Industry 4.0 in procurement

Literature shows minimal attention regarding the subject Industry 4.0 in procurement. This study contributes to the topic by adapting the purchasing year cycle and discussing it based on a multiple case study. The adapted framework contributes to further research and reveals that companies partially apply technologies belonging to the fourth industrial revolution.

For practical relevance, the nine conducted interviews identified, the status quo of Industry 4.0 in procurement. It was pointed out that Industry 4.0 in procurement is still in its infancy. Yet, most companies test pilot projects and are about to execute projects standing in line to be tested. Some companies described, that compared to other departments, the procurement department legs behind. Yet, the purchasing department is important regarding the future development. This engagement might lead to the conclusion that more attention will be drawn on Industry 4.0 in procurement. However, companies need to spend more time and effort on research for future developments in procurement and scholars need to pay particular attention to Industry 4.0 in procurement.

6.5 Recommendation for practice: use the adapted category sourcing cycle as guideline to implement Industry 4.0

It is suggested that companies should be guided in developments regarding Industry 4.0. This could be done by using frameworks such as the adapted purchasing year cycle, which features different aspects and opportunities concerning Industry 4.0 in procurement. A lack of interconnectivity and a rather abstract and uncertain future within companies was recognised. It is expected that companies start with new technological applications where the risk is rather low and it does not affect the core business. Following the framework could help companies to overcome uncertainties that appear due to the novelty of the topic. The ERP system received special attention in this paper. It is suggested as a unifying system for a company to encourage the connection to the suppliers. The application of the new developed purchasing year cycle can

help to restructure an organisation, to leave old hierarchies behind, and to develop and create new ideas. ERP systems are already common in different industries but the potential is not yet exploited and still implies a lot of potential in coherence with Industry 4.0.

6.6 Limitations and future research: an incomplete picture of Industry 4.0

In regards to the research, merely a certain group of potential interviewees was considering as relevant. Thus, limitations are inevitable. In coherence with the research, only people working in the procurement department or dealing with Industry 4.0 were considered as experts and came into question. There are practical constraints given, only nine interviews with German participants were conducted. This results in a rather incomplete picture of Industry 4.0 in procurement and shows a limited reflection of the status quo in this regard. Due to the small set of conducted interviews and the limited spread concerning the location of companies, one based in the Netherlands and the other seven in Germany, the findings have to be considered with premeditation for other industries or countries. The interviews' structure and phrasing might have influenced the responses of the interviewees. These likely result in a potential bias across all interviews.

Existing literature clearly lacks a specific definition regarding the fourth industrial revolution and further attention needs to be specifically drawn on Industry 4.0 in procurement. A more precise understanding of what Industry 4.0 means as well as opportunities for companies need to be developed. It is strongly suggested to use the adapted category sourcing cycle and adjusted the other fragments regarding Industry 4.0 as well as to extend and deepen it. Further research in Industry 4.0 in procurement is required to prove the research's findings and extend it with additional case studies.

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9. APPENDIX A1

9.1 Interview Questions

1.	To what extent are suppliers involved in regular processes in procurement?
2.	Do you have processes based on Industry 4.0 technologies that are already implemented in the company's day-to-day business? To what extent are there suppliers involved?
3.	Do you have processes based on Industry 4.0 technology implemented in the purchasing department? To what extent are suppliers involved in that process?
4.	Are you working on pilot projects concerning Industry 4.0 in procurement? To what extent are suppliers involved in pilot projects?
5.	Additionally to pilot projects, what are other projects that are standing in line to be tested? Do you currently involve suppliers in the development of new concepts? Are you planning on doing so in the future?
6.	What expectations do you have regarding Industry 4.0 in procurement?
7.	What is your vision for industry 4.0 in procurement?
8.	How far are other business divisions concerning Industry 4.0 in comparison?
9.	How is the collaboration between the different departments regarding Industry 4.0?
10.	What is the status of the purchasing department regarding Industry 4.0 within your company?

9.2 Interview Questions - German

1.	In wie fern sind Lieferanten in laufende Prozesse in der Beschaffung involviert?
2.	In wie fern werden bereits Technologien die Industrie 4.0 zugeordnet werden können im täglichen Geschäft angewendet? In wie weit sind Lieferanten involviert?
3.	Haben sie Prozesse, die Industrie 4.0 zugeordnet werden können bereits in der Beschaffung implementiert? In wie weit sind Lieferanten involviert?
4.	Arbeiten Sie an Pilot Projekten, die sich mit Industrie 4.0 in der Beschaffung befassen? In wie weit sind Lieferanten involviert?
5.	Zusätzlich zu Pilot Projekten, gibt es andere Projekte die darauf ‚warten' getestet zu werden? Haben Sie mit Lieferanten zusammengearbeitet um diese Konzepte zu entwickeln? Planen Sie Lieferanten in der Zukunft zu integrieren?
6.	Welche Erwartungen haben Sie an Industrie 4.0?
7.	Was ist Ihre Vision für Industrie 4.0 in der Beschaffung?
8.	Wie weit sind andere Geschäftsbereiche bezüglich Industrie 4.0 im Vergleich?
9.	Wie sieht die Zusammenarbeit in Ihrem Unternehmen bezüglich Industrie 4.0 aus?
10.	Welche Rolle nimmt die Beschaffung in Ihrem Unternehmen bezüglich Industrie 4.0 ein?

10. APPENDIX A2

10.1 Summary of nine different interviews

Left out due to confidential information.