Purchasing 4.0: An Exploratory Multiple Case Study on the Purchasing Process Reshaped by Industry 4.0 in the Automotive Industry

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Simon Gottge & Torben Menzel
Abstract

Title: Purchasing 4.0: An Exploratory Multiple Case Study on the Purchasing Process Reshaped by Industry 4.0 in the Automotive Industry

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Background: Rapidly transforming technologies and changing customer expectations trigger the fourth industrial revolution. This development, often referred to as ‘Industry 4.0’, is characterized by autonomously communicating and interacting technologies throughout the supply chain. Simultaneously, the importance of efficient purchasing processes in the automotive sector keeps growing as outsourcing and globalization tendencies increase. While Industry 4.0 publications are on the rise, little research is carried out on the impact on related supply chain functions, especially purchasing, calling for scientific investigations.

Purpose: The purpose of this thesis is to explore the influence of Industry 4.0 on purchasing at automotive manufacturers and further derive a visionary model of the reshaped purchasing process within the adjusted Purchasing 4.0 context.

Method: The deductive research is carried out as exploratory multiple case study. In three cases, qualitative data from four dyads is analyzed. Interviews hereby were conducted with 23 participants representing different perspectives, also including case-independent experts.

Findings & conclusion: Considering the influence of Industry 4.0 on purchasing, the research reveals, that new technologies and changes in manufacturing, integration and business context will impact the purchasing scope, collaboration, structure, and infrastructure. These changes include new components and different suppliers, a cross-functional and deeper supplier integration as well as collaboration platforms, holistic networks and assisting IT-systems.

In the reshaped purchasing process, strategic sub processes will become highly integrated and technology supported, leading to a co-creation of specification, explorative supplier selection, parameter-based quotations and negotiations, and autonomous re-negotiations of changes. The operative purchasing process on the other hand is strongly shaped by real-time data usage, creating interactive call-offs, real-time tracking, proactive trouble shooting and holistic supplier evaluations.

Keywords: Purchasing; Industry 4.0; Purchasing 4.0; Purchasing Process; Automotive
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<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>BI</td>
<td>Business Intelligence</td>
</tr>
<tr>
<td>B2B</td>
<td>Business to Business</td>
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<tr>
<td>CFT</td>
<td>Cross-Functional Teams</td>
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<tr>
<td>CPS</td>
<td>Cyber-Physical System</td>
</tr>
<tr>
<td>CPPS</td>
<td>Cyber-Physical Production System</td>
</tr>
<tr>
<td>EDI</td>
<td>Electronic Data Interchange</td>
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<tr>
<td>IoMT</td>
<td>Internet of Manufacturing Things</td>
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<tr>
<td>IoT</td>
<td>Internet of Things</td>
</tr>
<tr>
<td>IoS</td>
<td>Internet of Services</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>JIT</td>
<td>Just In Time</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>RFI</td>
<td>Request For Information</td>
</tr>
<tr>
<td>RFP</td>
<td>Request For Proposal</td>
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<tr>
<td>RFQ</td>
<td>Request For Quotation</td>
</tr>
<tr>
<td>ROCE</td>
<td>Return On Capital Employed</td>
</tr>
<tr>
<td>RQ</td>
<td>Research Question</td>
</tr>
<tr>
<td>SOP</td>
<td>Start Of Production</td>
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<tr>
<td>TCO</td>
<td>Total Cost of Ownership</td>
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1 Introduction

The following chapter will first provide a background to Industry 4.0, purchasing as well as the automotive industry. Building up on this, the relevance of the topic, existing research gaps and arising questions will be discussed and translated into research questions and purpose. At the end of the chapter the structure of this thesis will be outlined.

1.1 Background

Over the last decades, information technology has rapidly evolved, changing the business world. While in the beginning of the 21st century the importance of computer and internet increased, the third industrial revolution started to digitalize manufacturing (Zhou, et al., 2015). Nowadays, the information technology develops so rapidly, that the fourth industrial revolution is considered to already take place (Prause, et al., 2016).

This revolution is initiated through forces that can be described as a customer-pull as well as a technology-push. On one side, shorter development cycles, individualization on demand, flexibility in production, and required resource efficiency pull for this revolution in manufacturing (Lasi, et al., 2014). On the other side, technological developments like increasing automation, digitalization, and networking push customer-expectations leading towards the fourth industrial revolution (Forstner & Dümmler, 2014). This revolution is often referred to as ‘Industry 4.0’, a key term strongly promoted by the German government (Schlechtendahl, et al., 2015). Simplified, it can be described as organization of production-related processes based on technology and devices autonomously communicating and interacting with each other along the supply chain (Smit, et al., 2016).

The so called ‘SmartFactoryKL’ provides an example for the application of Industry 4.0 concepts, resulting in highly integrated, self-controlled operations (Qin, et al., 2016). These ‘Smart Factories’ are strongly equipped with sensors and autonomous systems. ‘Cyber-Physical Systems’ merge the physical with the digital level while the ‘Internet of Things’ enables interaction between machines and/or humans. Big Data & Business Intelligence extract valuable knowledge from complex structured, large data sets. Beyond manufacturing changes, new distribution and purchasing systems enable
customized product development through connected processes along all channels (Roblek, et al., 2016; Lasi, et al., 2014).

Considering these possibilities, applying Industry 4.0 in the automotive industry will result in highly dynamic operations, in which individualized vehicles become ‘Smart Products’ that autonomously coordinate assembly in a decoupled, fully flexible and integrated manufacturing network (Kagermann, et al., 2011).

Based on these technology enhancements, Industry 4.0 implies increased efficiency, quality, and flexibility for companies (Albers, et al., 2016; Weyer, et al., 2015; Broy, et al., 2010). Zhou et al. (2015) claim, that the German electronic industry is expecting their productivity to increase by 30% due to Industry 4.0. According to the consultancy Roland Berger, it can be expected that, in case of the automotive industry, Industry 4.0 will increase the ROCE (Return on Capital Employed) by 25%, while doubling the margin (Roland Berger, 2016). This is in accordance with Albers et al. (2016), who state that different studies indicate a productivity increase by up to 50%.

These benefits are based on automation of processes, increased amount of collected and accessible data, easier and faster use of data, and a focus on important tasks (Weyer, et al., 2015). The real-time information sharing in combination with enhanced data processing further allows faster and more flexible planning and reaction to problems (Weyer, et al., 2015; Zhou, et al., 2015).

At the same time, the importance of purchasing, the active managing of external resources, for the overall company performance continues to increase (Spina, et al., 2013). Outsourcing, globalization, and the switch from labor-intensive production to machine-based production can be seen as main reason for the increasing relevance of sound purchasing processes (Ferreira, et al., 2015; Spina, et al., 2013). Schneider and Wallenburg (2013) point out, that nowadays material costs account for more than 50% of the overall company costs. Wu and Chen (2015) even consider the value of purchased material to represent 60-80% of the turnover in manufacturing companies, with the automotive industry in the top range.

Therefore, by leveraging purchasing potentials, companies strive to achieve lowest cost, highest quality, and little risk while realizing synergies for increasing individualized products, which are developed and manufactured in complex value creation networks (Feng & Zhang, 2017; Panagiotidou, et al., 2017; Pascual, et al., 2017). Increasing
customization and short product life cycles require fast reaction times, representing a challenge in today’s purchasing (Rosar, 2017). The sheer mass of information and communication purchasers need to handle for strategic and operative activities is ever increasing, creating another immense challenge (Schneider & Wallenburg, 2013).

This effects all sub processes of the strategic process from definition of specifications and supplier selection up to negotiations and contract agreements as well as the operative purchasing process, comprising of ordering, order expediting and evaluations (van Weele, 2014).

Most affected by these developments is the automotive industry, which on one side is renowned for its pioneer role concerning innovative manufacturing strategies and on the other side requires highly efficient purchasing processes due to outsourcing levels of up to 80% (Stock & Seliger, 2016; Kagermann, 2015; Zhou, et al., 2015).

1.2 Problem Discussion

Changing manufacturing strategies, demand for translation into linked supply chain management practices. According to Robolledo and Jobin (2013) purchasing and manufacturing hereby form the core of the supply chain and consequently need strategic alignment and consistency.

The increasing amount of publications within the field of Industry 4.0 and the public attention for this topic outline the influence Industry 4.0 has for the future business world. Nevertheless, besides those general and in many cases very technical publications on Industry 4.0, only few researchers considered Industry 4.0 in a more holistic way. Hecklau et al. (2016) for instance focus on the possible influence on human resources. Other authors combine Industry 4.0 with lean manufacturing (Sanders, et al., 2016; Kolberg & Zühlke, 2015), logistics (Schuhmacher & Hummel, 2016) or certain industries (Li, 2016; Oesterreich & Teuteberg, 2016).

Nevertheless, there is further need for research that studies the influence of Industry 4.0 on other areas (Lasi, et al., 2014). Especially cross-discipline collaboration is scarcely researched. Kagermann et al. (2011), who initiated the Industry 4.0 movement in 2011, describe the key advantage to be optimization potentials for manufacturing and linked supply chain functions. These benefits mostly derive from ideal resource utilization and short reaction times which also are key to a competitive purchasing configuration.
(Rosar, 2017). While some linked functions are already explored such as Logistics 4.0, Purchasing 4.0 still lacks a clear definition and a corresponding analysis of influencing factors (Schuhmacher & Hummel, 2016).

The increasing relevance and challenges purchasing is facing require innovative solutions. While the importance of improved utilization of communication, transparency, and technologies is individually frequently explored, purchasing adoption needs to be considered in a more holistic view (Spina, et al., 2013; Glock & Hochrein, 2011). Exploring influencing factors of Industry 4.0 within purchasing in the automotive industry offers new approaches for dealing with many of the before mentioned aspects (Köle & Bakal, 2017; Papakonstantinou & Bogetoft, 2017; Bag, 2016; Knight, et al., 2016; Chang, et al., 2013).

The before mentioned anticipation, is confirmed by consultancy reports and trade journals, in which the potential of Industry 4.0 based purchasing adjustments are discussed. Exemplary contributions include: PwC (PwC, 2014), Accenture (Nowosel, et al., 2015) and Beschaffung aktuell (Mohr, 2016). PwC claims that 81% of the purchasing managers surveyed expect Purchasing 4.0 to follow on Industry 4.0 (PwC, 2014). Furthermore, a study carried out by BME, the German Association for Supply Chain Management, Procurement and Logistics, shows that 37% of German companies have already implemented Industry 4.0 elements. But only one third of these apply some form of purchasing adjustments so far (Pellengahr, et al., 2016).

How these adjustments will shape purchasing can best be explored through consideration of the purchasing process. The process perspective hereby allows to translate rather abstract ideas of influences into concrete changes down to the activity level. As Industry 4.0 influences cannot be generalized for every type of industry, the process view allows to further consider industry relevant characteristics. This process-orientation is confirmed by current research calling for a focus on sound purchasing processes as critical requirement for future success (Yu, et al., 2017; Knight, et al., 2016).

Due to the maturity in manufacturing practices as well as the importance of efficient purchasing processes, the automotive industry represents the best starting ground to explore influences and process changes in terms of Purchasing 4.0 (Stock & Seliger, 2016; Kagermann, 2015; Zhou, et al., 2015). The automotive industry encompasses all
forms of motor vehicles from different sectors and can be divided into automotive manufacturers, automotive supplier as well as sales organizations (Wei, et al., 2008). Considering the focus on purchasing, this research only examines automotive manufacturers and suppliers.

Reflecting on the challenges and growing importance of automotive purchasing, as well as the unexplored cross-discipline potentials of Industry 4.0, combining these fields is crucial for future research in this area.

1.3 Purpose & Research Question

The purpose of this thesis is to explore the influence of Industry 4.0 on purchasing at automotive manufacturers and further derive a visionary model of the purchasing process within the Purchasing 4.0 context. This is carried out through answering the Research questions on:

\[ RQ1: \text{How will Industry 4.0 influence purchasing of automotive manufacturers?} \]

\[ RQ2: \text{How will Purchasing 4.0 reshape the purchasing process of automotive manufacturers?} \]

1.4 Delimitations

The scope of research is restricted to the European automotive industry. The geographical focus is set as Industry 4.0 represents a concept mostly known in Germany and bordering regions, while the industry focus is set due to high relevance of Industry 4.0 in the automotive industry. To generate a specific purchasing frame, the purchasing process is restricted to the most relevant area for automotive purchasing, the direct purchasing of material for the serial production.

1.5 Structure & Approach

Subsequently to the introducing statements, a theoretical foundation of Industry 4.0 and purchasing is provided (see figure 1). Within the ‘Frame of Reference’ the respective conceptual understanding for the research is operationalized and the research model illustrated. Based on empirical data from automotive manufacturers and suppliers an empirical description of three case studies and the fundamental empirical findings are presented. The following chapter addresses the research questions. Firstly, single cases are analyzed, which are secondly cross-analyzed supplemented with supporting
empirical material from expert interviews. The cross-case analysis of RQ1 hereby generalizes a Purchasing 4.0 understanding, while RQ2 provides a vision for a ‘smart purchasing process’. Finally, findings are discussed and critically reflected before a conclusion is drawn.

![Research Design](image)

*Figure 1: Research Design*
2 Methodology

Within the methodology chapter the underlying methodological choices are discussed and presented. To ensure the overall methodological fit, the choices are broken down from philosophy till research quality. Additionally, ethical consideration within the research are presented.

2.1 Research Philosophy & Paradigms

The research philosophy relates to the development and nature of knowledge (Saunders, et al., 2016). Guba and Lincoln (1998) describe the research philosophy to be strongly influenced by the basic belief systems based on epistemological and ontological assumptions. Simplified this concerns the worldview of the writers in terms of legitimate research.

Epistemology is concerned with what can be regarded acceptable knowledge (Bryman & Bell, 2011). The ontological assumptions on the other hand concern the form and nature of reality (Guba & Lincoln, 1998). Considering these fundamental questions, a close interrelation needs to be respected, as the research methods must fit to the corresponding predetermined methodology.

The major research paradigms are positivism, postpositivism, critical theory and constructivism (Eriksson & Kovalainen, 2016). The positivist research philosophy is characterized by an objective view on the research phenomena (ontology) with little personal attachment involved in the research process (epistemology). Positivist researchers aim for explanations rather than interpretations (Bryman & Bell, 2011). Postpositivism could be described as reformed version of positivism, being more critical concerning basic underlying assumptions. Critical theory even leans towards constructivist thinking with concerns on identification of structures of the world (Eriksson & Kovalainen, 2016). On the other side of the spectrum of research metaphysics, constructivism, a dominant form of interpretivism, can be found (Eriksson & Kovalainen, 2016). This believe systems is strongly shaped by a subjectivist view (epistemology), the consideration of relativism and local/specific constructed realities (ontology) and a hermeneutical methodology (Guba & Lincoln, 1998). This means, that realities are considered intangible, local, mental constructions, and depending on the individual holding the constructions. Reality therefore is not ‘less true’ but differently
sophisticated. The researcher is seen as interactively linked to the research object. Therefore, findings are created by the investigators. Methodological this results in individual constructions between and among research and object. Interpretations can be performed, compared, and contrasted through hermeneutical techniques (Guba & Lincoln, 1998). Hermeneutics, as key methodology for constructivism, aims to understand texts as interactions. The meaning hereby is generated by considering the reader (researcher) but also the text producer (participant). Consequently, the results of refined analyses need to be seen relative to the reading situation (Mayring, 2014).

Motivated by the aim of this thesis, to explore and comprehend a real-life phenomenon to generate general information and create an abstract model from the construction, a relativist ontology within the constructivist paradigm is presumed. The researchers aim to provide a greater understanding of the phenomenon through interpretations of its characteristics. Instead of aiming for an absolute truth, an understanding is created through considerations of underlying circumstances. Considering Berger and Luckmann’s (1967) basic assumptions on constructivism, this paradigm allows to critically consider taken-for-granted knowledge and seemingly objective structures and processes, while promoting a close relationship between research field and researcher. Further, this paradigm allows to analyze social actions from the actors’ standpoint (Tracy, 2013), which is highly relevant for this research when considering the multiple perspectives that are included.

2.2 Research Strategies

Concerning the research strategy, different distinctions need to be made. Firstly, the relation between knowledge and the problem can be differentiated. Exploratory research is conducted when little is known about a phenomenon with the aim to better understand the nature of a problem (Sekaran, 2003). Descriptive studies, on the other hand, describe the characteristics concerning variables of interest in a situation (Sekaran, 2003). Explanatory research aims at explaining relationships between variables to deeply study a problem or a situation (Saunders, et al., 2016).

As the knowledge base of this research cannot be considered rich enough, it needs to be viewed as exploratory research. A clear idea and purpose as well as exploration criteria are nevertheless developed before data collection, in accordance with Yin (2014).
Secondly, a distinction needs to be made in terms of data foundation. In this regard, quantitative research is concerned with numerical data and mostly related to a deductive approach in order to test theories (Saunders, et al., 2016). Qualitative research, on the other side, is intended to explore the ‘how’ (processes) and ‘why’ (meaning) behind phenomena (Cooper & Schindler, 2011). When it comes to deciding, which research strategy suits the research, one should consider the main differences of qualitative and quantitative research: qualitative research makes uses of words, while quantitative research uses numbers; qualitative research centers around meaning while quantitative research considers behavior; qualitative research is based on the logic of inductive inquiries, while quantitative research supports hypothetic deductive thinking. Finally, qualitative research has less power to achieve generalizations (Brannen, 2007).

Considering novelty of the phenomenon studied as well as the focus on processes, an exploratory qualitative research is most suitable. This is also conform with the type of research questions that center around exploring ‘how’ purchasing is influenced and the purchasing process reshaped. Further, the conducted research at the current stage offers no possibility for quantifications and testing of hypothesis.

2.3 Research Approach

Based on the nature of research within a field and the influence of existing theory on the topic, a deductive, inductive or abductive approach can be used (Saunders, et al., 2016). Induction proceeds from empirical research to theoretical results (Eriksson & Kovalainen, 2016). This approach is characterized by a higher flexibility and lower degree of predefined structures and is mostly linked to qualitative research. Hardly any research represents a purely inductive approach as some form of prior theoretical understanding of phenomena mostly exists (Perry, 1998). Deduction bases knowledge on theory as first source of knowledge. This means that theory guides the research (Bryman & Bell, 2011). Based on what theoretically is known, hypothesis or propositions can be tested/deduced. (Eriksson & Kovalainen, 2016). Abduction often is referred to as combination of inductive and deductive research approaches. It moves from basic descriptions and meanings towards explanations of phenomena (Eriksson & Kovalainen, 2016). The combination of inductive and deductive approaches therefore often can be considered advantageous (Saunders, et al., 2016).
The conducted research can neither be classified as purely inductive nor deductive. It can be seen as deductive research with inductive elements. Based on the deductive stance the research is based on, a theoretical foundation and a tentative idea on propositions concerning relationships between concepts exist (Saunders, et al., 2016). A search for causal relationships is created but within a less structured operationalization approach to permit the creation of alternative explanations. Following the inductive logic, understanding of the collected information is created through the analysis and a form of conceptual framework is formulated. While the study was set up prior to data collection (deduction), empirical data was gathered within a longer time frame of eight weeks allowing iterative influence on follow-up interviews (inductive).

2.4 Research Design & Method

Several different methodologies can be found in social research. Commonly used methodologies include: surveys, case studies, experiments, ethnography, action research, grounded theory and many more. When it comes to choosing, the research methodology needs to facilitate the accomplishment of the individual research goals (Quinlan, 2011).

Case studies can be defined as in-depth study of bounded entities (Quinlan, 2011). Eriksson and Kovalainen (2016) describe, that both single and multiple case studies are suitable to examine matters connected to industrial areas in businesses. Major themes include effects on industries as well as processes and changes in organizations. Dubois and Araujo (2007) hereby mention the high relevance of case research in the field of purchasing and supply chain management. This can be explained through the benefits for research in business networks as challenges like boundaries, complexity and case comparisons can be considered (Halinen & Törnroos, 2005).

Single case studies are most suitable when the phenomenon is most likely a rare or specific phenomenon as they allow an in-depth-analysis (Yin, 2014). Purchasing can be seen as highly relevant in many businesses, while the importance of efficient processes is especially critical in strongly outsourced industries like the automotive sector (Schmitz & Platts, 2004). Industry 4.0, with its highly innovative tendencies is not restricted to a certain case company but can rather be found in entire industries, especially the automotive industry. The topic at hand nevertheless requires an in-depth approach as well as the consideration of interacting parties within a company and even
an interlinked supply chain. To consider the different contexts and setting within this industry and allow further generalizations, this research considers multiple cases within the automotive industry.

The research, more precisely is conducted as embedded multiple case study, meaning that multiple case studies contain multiple units of analysis for each case (Yin, 2014). The units of analysis can be described as purchasing-sales interface within dyads (explained in the following chapter).

2.5 Population & Sampling

The population for this research encompasses a subgroup of the European automotive industry. This subgroup contains automotive manufacturers and supplier. Beyond that population, experts are considered within the field of purchasing. Due to the case research method, a non-probability sampling technique is chosen (Saunders, et al., 2016). To reach an adequate number of participants, two common types of non-probability were mixed, purposive sampling and snowball sampling. The applied purposive sampling strives to include the participants which are required for answering the research questions. Hereby a variety of participants are included that differ in terms of characteristics (Bryman & Bell, 2015). Further, when participants could act as some form of case promoters, they were further asked to refer the research proposal to other potential participants, leading towards snowball sampling (Cooper & Schindler, 2011). Clear sampling criteria were defined beforehand, restricting manufacturers and suppliers to knowingly Industry 4.0-related organizations. Further, industry experts (case support) were selected based on current publications and statements within trade magazines and online publications. Through this approach 23 participants are obtained through the initial addressing of 62 potential research partners.

The research object of this study are dyads, following the evidence of research along the buyer-supplier relationship within the automotive industry (Pereira, et al., 2011). Four dyads are hereby structured into three cases based on a focal company, the automotive manufacturer. Each case comprises of interviews with the management and purchasers at automotive manufacturer as well as sales-related functions at the suppliers (see figure 2).
A total of 18 case participants from seven organizations was obtained (see table 1). To validate cross-case analyses, five experts are interviewed, four of these with consultants and one with a representative of a public institute (see table 2).

<table>
<thead>
<tr>
<th>Organization</th>
<th>Position</th>
<th>Case A</th>
<th>Case B</th>
<th>Case C</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Management</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Purchaser</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Supplier</td>
<td>Sales related</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>7</strong></td>
<td><strong>6</strong></td>
<td><strong>5</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

Table 1: Overview Case Participants

<table>
<thead>
<tr>
<th>Organization</th>
<th>Position</th>
<th>Cross Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultancy</td>
<td>Purchasing expert</td>
<td>4</td>
</tr>
<tr>
<td>Institute</td>
<td>Purchasing researcher</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>-</td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>

Table 2: Overview Experts (Case Support)

The conducted interviews varied between 30 and 105 minutes. The total sample encompasses 20 hours of interviews which are selectively transcribed and represent the total material considered for the analysis. A detailed description on all participants can be found in appendix C.

2.6 Data Collection Model & Instrument

Empirical data can be collected through different techniques both for qualitative (numeric) or quantitative (non-numeric) data (Bryman & Bell, 2015). Qualitative case study research mostly collects empirical data through observations, interviews, and document analysis (Denzin and Lincoln, 1998).
Eriksson and Kovalinen (2016) describe that interview-based research is especially suiting for exploratory research. Therefore, semi-structured interviews are carried out targeting multiple informants from manufacturer, supplier, and consultancies. Semi-structured interviews can be described as outlined interviews with prepared key questions to lead the conversation (Saunders, et al., 2016). Research participants were provided with an interview guide to be able to prepare for the interview, as the topic represents quite complex and technical concepts. To ensure proper understanding, the interview guide was tested on a potential research participant leading to small adjustments in wording and structure. The interviews were carried out in person (10) or via phone (13).

Triangulation, the usage of multiple sources of evidence in research, is recommended for the case study approach (Yin, 2014). Considering the high restrictions in terms of confidentiality in the case context as well as the limited time scope of the research project solely interviews could be carried out.

Secondary data was further collected within the literature review, focusing on peer-reviewed journal articles but also conference proceedings and working papers as the topic has a very up-to-date nature. Especially when choosing conference proceedings, the reliability of the source was considered based on the reputation of the institutions and authors.

### 2.7 Data Analysis Methods

Several different methods for data analysis can be used for qualitative research (Yin, 2014). Qualitative research hereby diverges from quantitative studies as statistical relations can hardly be obtained and a statistical sufficient size of responses is seldom achieved. This also cannot be seen as major objective of qualitative research (Cooper & Schindler, 2011).

Commonly, a qualitative data analysis consists of some form of reduction or simplification of data, followed by a step of combining, interpretation or problem solving (Eriksson & Kovalainen, 2016). Within constructivism, analytical methods are largely based on hermeneutical approaches, which understand texts as interaction between conceptions of the researcher with intentions of research sources. Analysis
methods vary from: objective hermeneutics over grounded theory up to discourse analysis (Mayring, 2014).

Beyond these traditional methods, Mayring (2014) developed a sophisticated system to analyze even highly complex phenomena. The main idea of Mayring’s Qualitative Content Analysis (QCA) hereby is “to conceptualize the process of assigning categories to text passages as a qualitative-interpretative act, following content-analytical rules” (2014, p. 10). This approach is complemented by a quantitative step of analysis of frequencies from categories. The basic principles of the content analysis are: embedding of the material within the communicative context, a systematic, rule-bound procedure for analyzing text, a focus on categories, a theory-guided character of analysis, and the integration of quantitative steps of analysis (Mayring, 2014). Based on several key ideas, each research requires its own customized system, suiting the phenomenon and research question.

In the present research, the foundation of data analysis can be described as selective protocols, which represent focused interview transcripts (Mayring, 2014). The smallest component of material to be assessed (coding units) are single words within one interview (recording unit). For each interview, a brief analysis of the situation of origin is carried out beforehand. Due to the high amount of interviews to be considered, interviews are further paraphrased, and reduced to the required level of abstraction (Mayring, 2014).

The actual content analysis is carried out following the system of ‘parallel procedures’ (see figure 3). This means, that deductive category assignment is carried out alongside inductive category formation. The illustration below provides an overview on the steps of analysis. The deductive category assignment is based on predefined categories, following the operationalization within the frame of reference, which are detailed into sub categories. Coding guidelines are created by the researchers, followed by a first run through the material. Categories are then revised and coding guidelines adjusted, before a final working through the texts is carried out. Finally, category frequencies and contingencies are interpreted. Simultaneously, inductive category formulation is carried out. This means, that while texts are analyzed, new categories are created. When reaching a sufficient level of categories, texts are revised and inter-coder agreements
reworked before starting the final work through all material. The last step here also comprises of frequency analysis and interpretation.

<table>
<thead>
<tr>
<th>Deductive Category Assignment</th>
<th>Inductive Category Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Definition of the category system</td>
<td>1. Category formulation while working through the text</td>
</tr>
<tr>
<td>2. Definition of the coding guideline</td>
<td>2. Revision of categories after 50% of material is coded</td>
</tr>
<tr>
<td>3. Material run-through and preliminary coding</td>
<td>3. Final working through the material</td>
</tr>
<tr>
<td>4. Revision of categories/coding guideline</td>
<td>4. Building of main categories</td>
</tr>
<tr>
<td>5. Final working through the material</td>
<td>5. Intra-/Inter-coder agreement check</td>
</tr>
<tr>
<td>6. Analysis and interpretation of frequencies</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Parallel Procedure QCA (inspired by Mayring, 2014)

The outcome of this systematic content analysis is an extensive database for each case comprising of categories, subcategories, and corresponding frequencies and interpretations. A strongly comprised excerpt of this represents the empirical findings in the appendix A.

To create more robust findings, a cross case-synthesis, following Yin (2014), is carried out. Hereby each case is firstly considered as separate study. Through the early creation of uniform categories, cross-case conclusions are drawn under consideration of contrasting case settings. Following Yin’s research procedure for cross-cases, all evidence is considered, plausible rival interpretations are addressed and focus is set on the most significant aspects. Beside the usage of the researchers own expert knowledge, case study support is considered from five industry experts (see appendix C).

2.8 Research Quality

The research is based on the research criteria for qualitative research projects according to Gauch (2003) and National Research Council (2002) and follows the basics rules of: definition of significant research questions that allow empirical investigation; linkage of research with relevant theory; method application that directly enables investigations; coherent and explicit reasoning; as well as replication and generalization across several
studies. This orientation is further in line with Mayring’s idea on providing sufficient empirical data for a comprehensive qualitative research analysis.

Common instruments for research quality are reliability and validity. Herby, reliability represents a form of consistency that for example allows a reproduction of the research with same results. Validity further describes to what extent an instrument measured the intended phenomenon (Verhoeven, 2010).

Considering the constructivist research paradigm, the before mentioned more positivistic criteria is transferred to a different context. Consequently, the chosen research philosophy and qualitative research design calls for an adjusted research reflection (Guba & Lincoln, 1998). Nevertheless, Mayring (2014) argues, that validity and reliability needs to be considered but within a broader sense. Confirmatory with Guba and Lincoln’s (1998) call for adjusted criteria and Mayring’s (2014) understanding of a broader reflection, Yin (2014) offers a quality assessment based on construct validity, external validity as well as reliability.

Construct validity in Yin’s (2014) understanding means to identify the right operational measures for the phenomenon. External validity refers to a suitable definition of the domain of research finding generalizations. Reliability further implies that the operations of a study could be repeated leading to the same findings (Yin, 2014).

In accordance with Yin (2014), construct validity of this study is created through a clear definition of concepts and the identification of operational measures which is presented in the frame of reference. To increase construct validity, multiple sources of evidence (dyads plus case support) are considered, a chain of evidence is provided through iterative reasoning (building RQ2 on RQ1) and reviews by participants are used.

External validity is provided through early development of research questions to deduct appropriate theory and allow the creation of first theoretical propositions. Further, transferability is considered based on replication logic through a cross-case analysis.

When considering Yin’s (2014) call for reliability, one needs to consider the implications deriving from the constructivist research foundation of the study. When Yin refers to the possible reproduction of the same findings through later investigators, a paradigm conflict arises. As the constructivist paradigm considers the researcher as influencing element of the research, later investigations will consequently lead to
different findings. This conflict does not further influence the ultimate goal of Yin’s reliability measure to minimize errors and biases. Merely the interviewee-interviewer bias is diverging to Bryman and Bells (2015) understanding, considered as inevitable part of reality construction. Consequently, in accordance with Yin, the study strictly documents the procedures through the systematic analysis process of Mayring’s Qualitative Content Analysis. Further, case study protocols and databases are created through which both research questions are answered. As the analysis is carried out jointly by two researchers, an operationalization of research steps was inevitable to create inter-coder reliability (Mayring, 2014). This approach allows that an external researcher potentially could repeat the procedure of the study. To further promote reliability, Denzin and Lincoln’s (1998) creditability and dependability are considered through careful selection of participants and multiple perspective considerations.

Research quality further encompassed secondary data focusing on reliability. Considering the secondary data, the reliability of information can strongly be described by authority and reputation of the sources (Saunders, et al., 2016).

2.9 Ethics

Ethics in research can be described as norms and standards of behavior guiding moral choices. Ethical considerations in research focus especially on transparency in terms of data collection, analysis, and publication (Cooper & Schindler, 2011). The overall ethical goal within this thesis is not to harm any involved parties through the research activities. Participants therefore need to be informed about the procedure, their rights as participants, as well as the intended level of information usage. Before interacting, agreements on data recording and confidentiality need to be reached (Saunders, et al., 2016; Bryman & Bell, 2011). Confidentiality is highly relevant topic when considering the context of this study as information on purchasing practices can be highly sensible.

Consequently, a consent form is used to inform the research participants about the research, data usage and publications (see appendix D). According to the request of the participant, confidentiality is provided to the required extend. This includes concealment of company names, interviewee names, records and transcribed interviews (Easterby-Smith, et al., 2015).
Resulting from the overall feedback of research participants, company names, positions as well as names are not disclosed. Further, empirical data is only provided on a higher level of abstraction to prevent creation of conflicts between the different parties within the cases.

2.10 Summary of Methodological Choices

The summarizing table below presents all methodological choices that build the scientific foundation for the research project (see table 3).

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research paradigm</td>
<td>Constructivism</td>
</tr>
<tr>
<td>Research strategy</td>
<td>Exploratory, qualitative</td>
</tr>
<tr>
<td>Research approach</td>
<td>Deductive with inductive elements</td>
</tr>
<tr>
<td>Research design</td>
<td>Multiple case study</td>
</tr>
<tr>
<td>Population &amp; sampling</td>
<td>Non-probability (purposive, snow-ball)</td>
</tr>
<tr>
<td>Data collection model</td>
<td>Interviews (personal or phone)</td>
</tr>
<tr>
<td>Data analysis model</td>
<td>Qualitative content analysis, cross-case analysis</td>
</tr>
<tr>
<td>Research quality criteria</td>
<td>Construct validity, external validity, reliability</td>
</tr>
<tr>
<td>Ethical remarks</td>
<td>Protection through consent form and anonymity</td>
</tr>
</tbody>
</table>

*Table 3: Summary of Methodological Choices*
3 Theoretical Framework

The theoretical framework presents the fundamental concepts of Industry 4.0 and purchasing. As both topics present a broad understanding within the scientific community, definitions and understanding are firstly discussed and secondly the own understanding is presented. Related conceptual implications for this research are reduced to the required level to provide a solid base for answering the formulated research questions.

3.1 Industry 4.0

The manufacturing industry, a sector of the economy that processes materials to produce goods, iteratively developed into a highly mechanized and automatized business. The major technological leaps initiating a new era for production are referred to as ‘industrial revolutions’ (Lasi, et al., 2014). Ex-post this development can be differentiated into: mechanization (1st industrial revolution); exploitation of electricity (2nd industrial revolution); up to the digitalization (3rd industrial revolution). Based on advanced digitalization, networks and automation the 4th industrial revolution is presumed to take place presently (Lasi, et al., 2014).

3.1.1 Towards the Fourth Industrial Revolution

The third industrial revolution started in the 1970s with the emergence of advanced electronics and IT enabling first automations of production processes. This industrial revolution is also referred to as the digital revolution (Hermann, et al., 2016). The fourth industrial revolution builds on the digitalization, further advancing it through internet and future-oriented technologies including ‘smart objects’. This creates the vision of efficient modular manufacturing systems, in which products control their own production process (Lasi, et al., 2014). This revolution is characterized by digitalization and full automation processes, the advanced use of electronics and IT not just in manufacturing but also in all related areas (Roblek, et al., 2016).

The triggers for Industry 4.0 can on one side be described as customer-pull, as individualization, flexibility, quickness and resource efficiency become increasingly important. On the other side, a technology-push can be found with increasing automation, digitalization and networking applications (Lasi, et al., 2014).
The fourth industrial revolution is the first transformation which is predicted a-priory and not observed ex-post (Hermann, et al., 2016). It can be argued, whether this is just a continuation of the third industrial revolution or the actual beginning of a new era, the fourth industrial revolution. Future researchers need to critically analyze the disruptiveness and leap in productivity as well as generalization beyond location and industries. Supporters of the idea emphasize the disruptive potentials through linking possibilities of previously isolated elements (Smit, et al., 2016). The economic impact of this fourth industrial revolution is expected to be immense based on predicted effects on effectiveness and development of innovative business models (Hermann, et al., 2016).

3.1.2 Defining Industry 4.0

The term ‘Industry 4.0’ is often used as synonym for the fourth industrial revolution (Oesterreich & Teuteberg, 2016). The concept of Industry 4.0 was initiated by the research union ‘Economy-Science’ in 2011 and further developed by the German National Academy of Science and Engineering (acatech). The core idea behind Industry 4.0 was strongly promoted by the German chancellor during the Hannover Fair in 2011 (Smit, et al., 2016; Wang, et al., 2016). First detailed elaborations were made within a manifesto published by acatech in 2013 (Kagermann, et al., 2013).

The terminology ‘Industry 4.0’, constructed to characterize the planned fourth industrial revolution, has its root in software versioning terminology to emphasize the role of IT (Lasi, et al., 2014). Industry 4.0 (originally German: ‘Industrie 4.0’) is the common term used in and around Germany. Other regions refer to similar developments by ‘Industrial Internet’ (USA) or ‘Internet+’ and ’Made in China 2025’ (China) focusing stronger on internet revolutions (Qin, et al., 2016; Stock & Seliger, 2016; Wang, et al., 2016).

There is no clear or commonly accepted definition of Industry 4.0 (Pfohl, et al., 2015; Brettel, et al., 2014). Even the key promoters of Industry 4.0 (Kagermann and colleagues) rather describe a vision and basic technologies than providing a clear definition (Hermann, et al., 2016).
Published definitions strongly vary in terms of perspective and scope. To discuss the different types of definitions, a categorizations system is created by the authors of this thesis to classify viewpoint according to the definition approach:

**Origin-based definitions:** Some authors see a rather project-oriented character behind Industry 4.0. With its planned nature, Lasi et al. (2014) describe Industry 4.0 as umbrella term for a German future project included in the ‘high-tech strategy 2020’. Wang et al. (2016) also refer to Industry 4.0 as strategic initiative of the ‘High-Tech Strategy 2020 Action Plan’.

**Micro - Manufacturing-based definitions:** Very broadly speaking, define Oesterreich et al. (2016) Industry 4.0 as innovative, advanced manufacturing concept. Smit et al. (2016) state that Industry 4.0 describes a set of technological changes in manufacturing. Further, Hermann et al. (2016, p. 3928) expand this definition through their understanding of Industry 4.0 as “convergence of Industrial production and information and communication technologies”. Zhou et al. (2015) conformingly describe Industry 4.0 as flexible system involving digital manufacturing, network communication and automation technologies.

**Macro - Value chain-based definition:** From a macro perspective, Industry 4.0 can be described as a network of value creation modules (factories) which require cross linkage through the entire value chain. This striving for intelligent network creates a need for innovative changes of business models. The involved parties, enabled through the continues exchange of data, herby become linked smart factories (Stock & Seliger, 2016). According to Kolberg and Zühlke (2015) Industry 4.0 in this regard aims for optimizing value chains through implementation of autonomously controllable and dynamic manufacturing.

**Effect-based definitions:** According to Roblek et al. (2016), Industry 4.0 can be defined through its effects, as industry transformation through progress in digitalization of production, automation and linking manufacturing in supply chains. Pfohl et al. (2015, p. 37) further define that: “Industry 4.0 is the sum of all disruptive innovations […] to address the trends of digitalization, autonomization, transparency, mobility, modularization, network-collaboration, and socializing of products and processes.”

**Technology-centered definitions:** Technical definitions vary especially in terms of coverage of technologies. Wang et al. (2016, p. 2) only refer to Industry 4.0 as
“production oriented Cyber-Physical Systems that integrate production facilities, warehousing systems, logistics, and even social requirements to establish the global value creation networks”. Referring to Kagermann et al. (2013) Industry 4.0 can be defined as the integration of Cyber-Physical Systems in production and logistics. Beyond that, the authors include the application of Internet of Things in industrial processes in their definition. Consequences are hereby expected for the entire value chain and business models. Sanders et al. (2016, p. 816) elaborate further: “Industry 4.0 is the fourth industrial revolution applying the principles of cyber-physical system (CPS), internet and future oriented technologies and smart systems with enhanced human-machine interactions”.

Working definition for this thesis:

Based on the holistic effect-based definition of Roblek et al. (2016) and the technology-centered definitions of Sanders et al. (2016) and Kagermann et al. (2013), the working definition for this thesis is: Industry 4.0 is the industry transformation through digitalization and automation of production and industrial processes in linked supply chains, enabled through internet and future oriented technologies and smart systems.

3.1.3 Fundamental Technologies

Industry 4.0 can be described as an umbrella term comprising of several underlying concepts. There are several different opinions on the amount of fundamental concepts as classification and distinctions in many cases are difficult to make (Lasi, et al., 2014).

To discuss which underlying concepts are the foundation for Industry 4.0, a thorough research revealed four literature reviews on that topic (Hermann, et al., 2016; Oesterreich & Teuteberg, 2016; Pfohl, et al., 2015; Brettel, et al., 2014)

Pfohl et al. (2015) developed a sound mind map of all technologies that are commonly referred to within the context of Industry 4.0. The amount, complexity and interlinkage hereby illustrates why Industry 4.0 is hard to grasp in its totality (figure 4).
An encompassing content analysis by Oesterreich and Teuteberg (2016) on technology concepts published within Industry 4.0 publications, reveals the core concepts to be: Internet of Things and Services, Cloud Computing, Big Data, Smart Factory and Cyber-Physical Systems. Hermann et al. (2016) further claim that the core technologies only comprise of Cyber-Physical Systems, Internet of Things, Internet of Services as well as Smart Factories. Roblek et al. (2016) share this opinion, which can probably be explained with a strong manufacturing focus of the researchers.

**Considered technology scope:**

Acknowledging Industry 4.0 to not only be restricted to manufacturing, this study leans towards the understanding of Oesterreich and Teuteberg (2016) including data processing technologies as key component of Industry 4.0. This understanding finds
many supporters in very recent research on Industry 4.0 (Albers, et al., 2016; Kang, et al., 2016; Wang, et al., 2016).

3.1.3.1 Cyber-Physical Systems

Cyber-Physical Systems fuse the physical and the virtual world (Hermann, et al., 2016). Strongly simplified it can be said that CPS consist of software integrated in hardware like sensors, processors and communication systems, allowing autonomous exchange of information and interactive control (Smit, et al., 2016).

The term CPS originates in the relation of a physical layer (hardware like sensors) and a cyber layer (software for information and communication) (Kang, et al., 2016). This means, that computation and physical processes are integrated. Computer systems monitor and control the physical process with loops and effects from both computations and the physical process (Hermann, et al., 2016; Roblek, et al., 2016). CPS consequently can be described as embedded systems containing powerful microcomputers equipped with sensors and actuators (Kagermann, 2015).

These systems are continuously exchanging information with each other in real-time virtual networks (Stock & Seliger, 2016). Data is hereby transferred through clouds within the Internet of Things. Information exchange also exists in a sociotechnical system with operators through the usage of human-machine-interfaces (Stock & Seliger, 2016).

CPS can be found in several application areas, such as aerospace, automotive, transportation or manufacturing (Kang, et al., 2016). When referring to CPS within a manufacturing context the term Cyber-Physical Production System (CPPS) often is used (Zhou, et al., 2015). Cyber-Physical Systems enable the intelligent cross-linking and digitalization in manufacturing systems, but when considering the holistic usage of information and communication technologies, all supply chain activities can be imbedded (Stock & Seliger, 2016).

3.1.3.2 Big Data & Business Intelligence

Big Data commonly describes wide ranging, complex structured and large data sets that are difficult to analyze with traditional data processing methods (Kang, et al., 2016). Through Big Data new processing technologies are used to extract valuable information from various data types to achieve a deep understanding and create knowledge (Zhou, et
al., 2015). Data hereby is captured, curated, stored, shared and analyzed through special technical systems (Kang, et al., 2016). With Business Intelligence, this data can be mined by smart algorithms based on probability calculations and correlations. Subsequently, identified patterns are correlated to produce valuable new knowledge (Kagermann, 2015). In this context, cloud computing provides affordable storage to handle the immensely increasing volumes of data being produced by for example smart objects (Kagermann, 2015).

In the manufacturing context, Big Data is seen as a solution for currently existing production problems. Process mining allows real-time monitoring and control while decision-making is assisted as raw data can be transformed to actionable knowledge (Kang, et al., 2016). Further, production efficiency is improved through better planning and scheduling based on data mining and stochastic simulations. Advanced manufacturing analytic platforms hereby support process optimizations through indication-based and pattern-based data mining (Kang, et al., 2016).

3.1.3.3 Internet of Things

The internet is going through a major expansion based on mobile communication technologies as well as new internet protocols enabling further interactions (Kagermann, 2015). The Internet of Things (IoT) can be described as enabling things/objects (e.g. sensors, mobile phones etc.) to interact and cooperate with other ‘smart’ things/objects to reach common goals (Hermann, et al., 2016). The IoT is a network of sensors, software, and embedded things (physical objects). It provides the infrastructure to integrate the physical world into computer-based systems and thereby makes objects sensed and self-controlled (Kang, et al., 2016). Related to the Internet of Things is the Internet of Services, which refers to Big Data and cloud driven services offered and utilized within the value chain (Smit, et al., 2016).

In the context of manufacturing, IoT is also referred to as IoMT (Internet of Manufacturing Things) (Kang, et al., 2016). It can even be claimed, that Industry 4.0 is the application of IoT in the manufacturing context (Smit, et al., 2016).

IoT provides the infrastructure for other technologies such as CPS and thereby enables Smart Manufacturing. It can further be seen as a platform for integration of different systems as well as the interface basis towards the operators (Kang, et al., 2016).
3.1.3.4 Smart Factory

The future vision of Smart Factories can be described as integrative factory system. Connected manufacturing resources (sensors, actuators, robots etc.) promote a conscious and intelligent system, controlling and maintaining its own operations (Qin, et al., 2016). Smart Factories are factory systems that assist workers and machines based on information from the physical and virtual world (Hermann, et al., 2016). Smart Factories comprise of dynamic and flexible operations. Hereby, electronical sensors, actors and self-controlling systems support manufacturing practices to improve processes via self-optimization and allow autonomous decision-making (Roblek, et al., 2016). Therefore, they can be seen as manufacturing solutions to cope with increasing complexity in production through flexible and adaptive production processes (Kang, et al., 2016).

Many processes such as design, planning, and production in Smart Factories are simulated as modules but closely end-to-end interconnected. This allows interdependent control and decentralization (Qin, et al., 2016).

Smart Factories make use of further ‘smart’ solutions. Smart Data is generated through structuring of data from Big Data to achieve knowledge advances and support decision making throughout the entire product lifecycle (Stock & Seliger, 2016). Smart Products entail microchips and sensors enabling communication with other objects and humans via the Internet of Things (Roblek, et al., 2016). These products consequently communicate with each other and their environment, influencing the arrangement of the manufacturing systems (Brettel, et al., 2014). Smart Logistics further uses CPS to support the internal and external material flow (Stock & Seliger, 2016).

3.1.4 Industry 4.0 Business Implications

Industry 4.0 comes with several business implications. In the following, these are divided into technological enhancements, implications for automotive manufacturing, integration implications and implications for the business context.

3.1.4.1 Technological Enhancements

The technologies related to Industry 4.0 can be seen as key implication for business. The described technologies are hereby expected to strongly enable digitalization, automation and closer networking (Forstner & Dümmler, 2014).
Considering organizational changes due to the technological variables of Industry 4.0, the biggest impact is expected to be within production and distribution but also within purchasing (Roblek, et al., 2016; Pfohl, et al., 2015). Changing IT-Infrastructures and Business Intelligence creates cost reduction opportunities while improving transparency (Pfohl, et al., 2015). Suppliers for example can be chosen flexible and autonomously based on software solutions. Further changes for production and distribution are strongly based on miniaturization of electronics, which enables digitalization and real-time information sharing (Pfohl, et al., 2015).

### 3.1.4.2 Industry 4.0 in Automotive Manufacturing

As discussed before, Industry 4.0 is considered as advanced manufacturing concept comprising of the usage of future technologies (Hermann, et al., 2016; Oesterreich & Teuteberg, 2016; Zhou, et al., 2015).

The concept of the Smart Factory hereby describes the changes in manufacturing quite comprehensive. The implications for automotive manufacturing can be described as shift from sequenced car manufacturing on a production line towards a decoupled, fully flexible and highly integrated manufacturing system (Kagermann, et al., 2013). This means, that today’s production set up, which is characterized by a static production line with narrow functionality and less customizing potential is replaced. Automotive manufacturing in Industry 4.0 will be based on dynamic production lines controlled by ‘smart products’ (Kagermann, et al., 2013). A dynamic reconfiguration of workstations allows the production of highly individual variations at any time, while production planning is autonomously managed to prevent bottle necks. The central component for the holistic integration of operations hereby can be supported by an advanced IT system (Kagermann, et al., 2013).

This change will not just influence the manufacturing system at Original Equipment Manufacturers (OEMs) but needs to be considered within the entire value chain, consequently also at suppliers’ operations (Stock & Seliger, 2016; Kolberg & Zühlke, 2015).

### 3.1.4.3 Integration

Considering the described macro perspective on defining Industry 4.0, changes in integration will create business implications (Stock & Seliger, 2016). This change in
integration comprises of inter and intra company cross-linking and digitalization of value creation throughout all phases of the product life cycle across different hierarchical levels (Stock & Seliger, 2016).

The main paradigm hereby can be described with three different forms on cross-linked integration approaches (Oesterreich & Teuteberg, 2016; Smit, et al., 2016; Stock & Seliger, 2016; Kagermann, et al., 2013):

1. **Horizontal integration across the entire value creation network**: can be described as internal and external interlinking and digitalization of value creation. This allows real-time management from order placement till outbound logistics. The integration of IT processes, systems and information between organizations hereby supports close collaboration.

2. **End-to-end engineering across the entire product life cycle**: includes the intelligent linking and digitalization through all phases within a product life cycle. This comprises value chain activities from design up until after sales services.

3. **Vertical integration and networked manufacturing systems**: entails the cross-linking and digitalization through different levels of aggregation and hierarchy within a company to promote cross-functional collaboration.

### 3.1.4.4 Business Context

Industry 4.0 should not be limited to advances in technology, production, and integration, but rather needs to be seen as a disruption of business as a whole (Roblek, et al., 2016). Pfohl et al. (2015) developed a framework to assess potentials and challenges of Supply Chain Management in Industry 4.0. They consider the functions of production, distribution, purchasing and sales as strongly influenced through a changing business context (Pfohl, et al., 2015).

Based on different publications, the authors of this thesis created a classification of contextual changes into: product, supplier, business model, and purchaser role changes.

The contextual changes are difficult to define, as they must be seen as highly industry or market related. Considering the context from a customer’s perspective, changed customer requirements like individualization and innovation expectations will create the need for different products (Lasi, et al., 2014). These customer requirements paired with
technological and integration advancements at the focal companies further impact the supply chain structure, consequently also the supplier base (Stock & Seliger, 2016). New technologies and structural changes also need to be explored in terms of changing business models that arise (Stock & Seliger, 2016). Finally, the aspect of human interaction is important to consider. From the perspective of human interaction, digital applications hereby change the roles and processes (Pfohl, et al., 2015).

3.1.5 Summary

Figure 5 illustrates the considered definition for Industry 4.0, the key technologies as well as the described business implications.

![Figure 5: Summary Industry 4.0](image)
3.2 Purchasing

Purchasing and its impact on the overall company performance is widely discussed in literature. Nevertheless, a clear and universal definition of purchasing is not established. This is based on different distinctions to related terms and a different understanding of the scope of purchasing. Consequently, this chapter starts with a discussion on purchasing definitions. Based on this definition, and different process models the automotive purchasing process is derived and sub processes are described.

3.2.1 Defining Purchasing

The varying understandings become obvious when exploring different terminology use. While Baily et al. (2015), Handfield et al. (2009), and Jonsson (2008) understand purchasing and procurement interchangeable, Russell and Thukral (2003), and Leenders et al. (2002) understand purchasing as part of procurement. Furthermore, Spina et al. (2013) as well as Leenders et al. (2002) consider the term supply management to be interchangeable to purchasing. Miemczyk et al. (2012) decide to treat purchasing, procurement, and sourcing as similar due to the minor differences that exist between the three terms.

Due to this, a clear definition of the term purchasing that will lead this paper is required, to assure the same understanding and focus of the term for the reader and research participants. Therefore, different definitions will be discussed to provide an overview of existing understanding and develop the purchasing definition for this paper.

Traditionale definition: As outlined by Handfield et al. (2009), Lysons and Farrington (2006), and Heinritz et al. (1991), traditionally purchasing was understood as buying material according to the five rights: right quality, right quantity, at the right price, from the right source, at the right time. This understanding of purchasing is not valid anymore, as today’s purchasing has become more complex and involves not only operative but also strategic objectives (Monczka, et al., 2009; Lysons & Farrington, 2006; Heinritz, et al., 1991).

Operative focused definitions: Today’s definitions differ mainly in the extent to which they are considering operative and strategic elements. Some authors, such as Chopra and Meindl (2016), Fawcett et al. (2007), and Russell and Thukral (2003) have a quite operative-centered understanding of purchasing. Russell and Thukral (2003, p. 326)
present a transaction and price oriented approach, as for them “Purchasing applies to the transactional functions of buying products and services at the lowest possible price.” (CIPS, 2017, p. 27) defines purchasing as acquiring “goods, works or services from a nominated supplier. Purchasing is a component of the wider function of procurement and consists of activities such as ordering, expediting, receipt and payment”.

*Strategic and operative focused definitions:* Nevertheless, most of the authors consider operative and strategic elements for their definition of purchasing (e.g. van Weele (2014), Spina et al. (2013), and Handfield et al. (2009)). A quite generic definition of purchasing that is considering operative and strategic elements is presented by Glock and Hochrein (2011, p. 149), who define purchasing “as the process of planning, implementing, evaluating, and controlling strategic and operative purchasing decisions for directing all activities of the purchasing function towards opportunities consistent with the firm's capabilities to achieve its long-term goals”

*Strategic focused definitions:* Handfield et al. (2009, p. 8) define purchasing as “a strategic approach to planning for and acquiring the organization’s current and future needs through effectively managing the supply base, utilizing a process orientation in conjunction with cross-functional teams (CFTs) to achieve the organization mission”. Building up on this definition, Spina et al. (2013, p. 1202) define purchasing as “strategic approach to planning for and acquiring the organization's current and future needs through effectively managing the supply base”.

*Holistic definition:* A quite far reaching definition is presented by Heinritz et al. (1991, p. 3), who define purchasing as being responsible for “finding new sources of supply, finding substitute products, making recommendations for specification changes that allowed for the use of less costly and scarce materials, and making changes in ordering and delivery patterns that resulted in lower levels of inventory”

A definition that is often referred to in the purchasing literature is van Weele’s definition of purchasing. Van Weele (2014, p. 8) defines purchasing as “The management of the company’s external 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 at the most favourable conditions”
Working definition for this thesis:

Considering above discussed definitions, this master thesis defines purchasing based on a combination of van Weele (2014) and Spina et al. (2013) as actively managing, planning and acquiring the external resources of all internal requirements in the most beneficial way for the company by considering the current and future needs of all internal interfaces.

3.2.2 The Automotive Purchasing Process

The purchasing process consist of several different sub-processes and tasks that together form the purchasing process (van Weele, 2014; Handfield, et al., 2009). Several interfaces between different functions, such as product development, logistics, or quality control, exist in the purchasing process and therefore requires a more holistic consideration than only focusing on the purchaser role (Fawcett, et al., 2007; Russell & Thukral, 2003). Even though there exist some generic elements and understanding, the purchasing process differs between different authors. Furthermore, it needs to be considered that company and industry specific characteristics and requirements have an influence on the purchasing process, especially on the level of used tools and involved tasks (van Weele, 2014; Handfield, et al., 2009). There exists no process model for automotive purchasing within current literature, consequently an own understanding has to be generated. To provide a more holistic understanding of different purchasing processes and motivate the choice of one underlying process, a comparison of different publications is conducted below.

3.2.2.1 Comparison of Different Purchasing Process Models

There exist several different understandings about the steps included in the purchasing process and how far the purchasing process reaches. While for Handfield et al. (2009) as well as Russell and Thukral (2003) the purchasing process starts with the demand forecast, Shao et al. (2008) see the strategy development as the starting point of the purchasing process. Contrary to that, for most of the authors the purchasing process starts with the recognition of need. In most cases this step is closely interlinked with the specification of demand. Even though Handfield et al. (2009), Shao et al. (2008), and Russell and Thukral (2003) consider the purchasing process to start at an earlier stage, they also consider this step in the purchasing process. Van Weele (2014) and Fawcett et
al. (2007) also include the make or buy decision in this step, while this is ignored by most authors.

All considered publications see these steps followed by the selection of suitable suppliers as well as the request for quotation (RFQ) or/and bidding, which then leads to the actual supplier selection. Besides that, some authors (e.g. Handfield, et al., 2009; Fawcett, et al., 2007; Samaniego, et al. 2006) consider the search for suppliers as a preliminary step for this, while the rest of the authors consider the purchasing process to make use of the existing supplier base.

While Shao et al. (2008) and Russell and Thukral (2003) consider contracting to follow the supplier selection, Fawcett et al. (2007), Samaniego et al. (2006), Lysons and Farrington (2006), Gadde and Håkansson (1993), and Heinritz et al. (1991) consider issuing the purchasing order (PO) as the next step. Contrary to that van Weele (2014), Handfield et al. (2009), Leenders et al. (2002), as well as Novack and Simco (1991) consider the supplier selection to be followed by contracting as well as the issuing of a PO.

Once the material is ordered, expediting of the order is considered by most authors as the next step (van Weele, 2014; Fawcett, et al., 2007; Gadde & Håkansson, 1993). Furthermore, other post-ordering related tasks can be found in the literature as being part of the purchasing process such as material receipt, inspection of materials, checking and paying the invoice, and record keeping.

Furthermore, van Weele (2014), Handfield et al. (2009), Shao et al. (2008), Fawcett et al. (2007), Russell and Thukral (2003), Leenders et al. (2002), as well as Novack and Simco (1991), consider the performance evaluation as important part of the purchasing process that is following the delivery. Additionally, some authors also consider the maintenance of relations of suppliers to be part of the purchasing process (Fawcett, et al., 2007; Russell & Thukral, 2003; Leenders, et al., 2002).

The table below (table 4) provides a detailed overview of the separate steps considered for the purchasing process by the selected authors.
To derive the automotive purchasing process from the before-mentioned set of understandings, several aspects need to be considered. Firstly, it is important to consider the underlying production context, for which materials are purchased. The automotive context can be described as industrial serial production, which lays the foundation for purchasing practices (Thun & Hoenig, 2011; Schmitz & Platts, 2003). Secondly, industry specifications in purchasing need to be considered. Simplified, these encompass: a structured tier network of suppliers, specific project related material requirements, high volume and long duration contract agreements, cross-functional involvement, high cost accounting focus, large supplier bases and close collaborations and integration in logistics (Pereira, et al., 2011; Thun & Hoenig, 2011; Koplin, et al., 2007; Schmitz & Platts, 2004; Schmitz & Platts, 2003).

Based on the industry setting and the literature review, van Weele’s (2014) purchasing process was selected as forming the base for the considered purchasing process of this thesis. This is the case as van Weele provides a quite comprehensive understanding of the purchasing process that covers most of the steps that are relevant for the purchasing

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<td>Select possible suppliers</td>
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<td>Supplier decision</td>
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<td>Contracting</td>
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<td>Paying invoice</td>
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<td>Record keeping</td>
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<td>Performance measurement</td>
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<tr>
<td>Maintain relationships</td>
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</table>

Table 4: Comparison of Purchasing Processes

3.2.2.2 Deriving the Automotive Purchasing Process
process based on the underlying definition of purchasing and the authors’ understanding of it. Especially with respect to the industrial serial production context of this thesis, van Weele’s purchasing process is considered as most adequate foundation. Furthermore, it offers a very structured and comprehensive deviation into sub processes. Van Weele (2014) is distinguishing his purchasing process into six sub-processes, namely define specification, select supplier, negotiation and contract agreement, ordering, expediting, and evaluation.

While for van Weele (2014) the make or buy decision is part of the purchasing process, this thesis is considering the make or buy decision to be excluded of the purchasing process as this is considered to be rather part of procurement and sourcing and is also ignored for the purchasing process by most of the studied publications.

Furthermore, the expediting sub process will be replaced by the order follow up sub process in this thesis, which is besides the tasks of the expediting sub process also including tasks such as quality inspection and handling of invoices which need to be considered in the automotive industry (Wei, et al., 2008).

3.2.2.3 The Strategic and the Operative Purchasing Process

The purchasing process can be divided into two parts, the strategic purchasing and the operative purchasing (Spina, et al., 2013; Glock & Hochrein, 2011). While the strategic purchasing is concerned with the management of the supply base and decision making in accordance with the overall company strategy, the operative purchasing is rather concerned with the actual acquisition of material and material flow (Spina, et al., 2013; Handfield, et al., 2009). Accordingly, the first three steps of the adjusted purchasing process can be categorized as strategic while the last three steps are operative (see figure 6).

![Figure 6: Differentiation Strategic and Operative Purchasing Process](image-url)
3.2.3 Purchasing Sub Processes

Even though the purchasing process is divided into six sub processes, the sub processes are closely related and building up on each other. According to van Weele (2014), the next step can only begin once the previous step is successfully performed. Therefore, careful consideration of requirements and issues for the next steps in the purchasing process is required, as interruptions or repetition of the purchasing process through changes or inadequate planning can lead to additional costs (van Weele, 2014).

The generic process that is forming the base for this chapter typically is only performed once, in the case of an initial purchase. Future straight or modified rebuys are, as outlined by van Weele (2014), only going through a part of the purchasing process, normally starting at the ordering point.

The following sub-processes are based on van Weele but adjusted according to understandings by other authors to provide a holistic understanding of each sub-process.

3.2.3.1 Define Specification

The define specification sub-process consists of two elements, the determining of the purchasing requirements and the development of the purchase order specification (van Weele, 2014; Shao, et al., 2008; Novack & Simco, 1991). According to van Weele (2014), first of all, the requirement of a using department needs to be determined. Based on the specifics of the requirement the elements of the purchase order specification can be identified (Shao, et al., 2008). A purchase order specification consisting of functional and technical specifications needs to be created (van Weele, 2014). This step requires the involvement of the purchasing department with other departments, especially the product development. According to Leenders et al. (2002) it can also be beneficial to already involve possible supplier in this step to enable cost reductions. Typically, the purchasing order specification consists, besides technical requirements, of information about quality, quantities, delivery time, place of delivery, as well as legal and environmental considerations (van Weele, 2014). Depending on the type of purchased product other elements such as maintenance and service requirements can be included as well.
3.2.3.2 Select Suppliers

To satisfy the identified need, suitable suppliers need to be identified (van Weele, 2014). Based on pre-defined evaluation criteria, the supplier market is screened and suppliers fulfilling the basic requirements are prequalified as potential supplier for the respective product. In this context, a request for information (RFI) might be send out to some suppliers to gather further specific information that are necessary for the supplier qualification but are not available so far.

Once the initial supplier base is identified, a request for quotation (RFQ) is send out to these suppliers. According to Leenders et al. (2002) as alternative to the RFQ, a request for proposal (RFP) can be used, which is asking the pre-selected suppliers to present a proposed solution for the specific requirement.

Depending on the type of product, different ways of offering and awarding the order are suitable. While for small purchases easy solutions, such as purchase cards should be considered, for purchases with a higher value bidding should be considered. In those cases where the price is the most crucial criteria for the purchase, reverse bidding might be the most suitable method. In purchases that are quite complex, have a high importance, and/or for which building up a long-term relationship to the supplier is important, the initial bidding process should be followed by negotiations.

Furthermore, according to van Weele (2014), the selection of the best supplier should not only consider the offered price but also other important factors, such as past performance, risk associated with the supplier, total costs of ownership (TCO), and quality.

Based on the received price offers in combination with the pre-defined ranking schemes one or more suppliers are selected for the final negotiation stage.

3.2.3.3 Negotiation and Contract Agreement

In the negotiation and contract agreement step, the main objective is to come to a final agreement on all specific elements of the purchasing agreement. Besides negotiations about the final price, other important contract elements such as payment terms, penalty clauses, or quality considerations are discussed in this step (van Weele, 2014). Furthermore, the legal aspects also need to be discussed and agreed on to enable a final contract agreement.
Besides the negotiation part, the buying company also needs to clarify in this sub-process which type of contract the most suitable for the respective purchase is (van Weele, 2014). This is especially crucial for routine purchases that are reoccurring over a certain time span (Fawcett, et al., 2007). In these cases, Fawcett et al. (2007) and Leenders et al. (2002) suggest the use of framework agreements and blanket orders.

Framework agreements predefine conditions, such as price, quantities, payment terms, with a supplier for purchases over a certain quantity or time frame (van Weele, 2014). Based on this, all requirements can be placed in form of call-offs under pre-agreed terms and no price agreement need to be reached for every single purchase (van Weele, 2014). As outlined by Handfield et al. (2009) contracts with a fixed price agreement can be differentiated into firm fixed price contracts and cost-based contracts. While in firm fixed price agreements the price stays the same over the complete span, in cost-based contracts the price can vary for each purchase based on defined factors such as material costs, inflation, or increasing learning curve (Handfield, et al., 2009). Van Weele (2014) in this context brings up following common types of cost-based contracts: fixed-price plus incentive, cost-plus contract, cost-reimbursable contract, agreement with price-adjustment.

### 3.2.3.4 Ordering

The characteristics of the ordering sub-process differ based on the contract decision that was taken in the previous step (Leenders, et al., 2002). In case of a single purchase, a purchase order will be created including all agreed conditions and send to the supplier (Lysons & Farrington, 2006). In case of framework agreements, blanket orders are created against which a material call-off is done whenever a requirement comes up (van Weele, 2014; Handfield, et al., 2009). The order or material call-off is typically initiated by a material requisition from a using department (Fawcett, et al., 2007).

### 3.2.3.5 Order Follow-Up

Order follow-up consists of several small tasks that need to be considered between the placement of an order/material call-off and the final settlement of the delivery. The overall goal of this sub-process is to make sure that the suppliers perform the delivery based on the agreed terms (van Weele, 2014). As outlined by Heinritz et al. (1991),
even though these tasks are in most cases not directly handled by the purchasing department, they still form an important part of the purchasing process.

One of these tasks is delivery time tracking. Leenders et al. (2002) point out that the frequency of delivery time control depends on the importance of the delivery. While for material for which an on-time delivery is crucial a continuous delivery time tracking should be applied, for less important material a routine status check that is performed in a certain interval is suitable (van Weele, 2014; Leenders, et al., 2002)

In case of delivery delays, trouble shooting becomes an important task. Solutions to speed up the delivery or to identify alternative sources of supply need to be created (Fawcett, et al., 2007).

Besides the delivery of the material, the receiving of the material is also important. The correctness of the delivery in terms of specification, quality, and quantity is checked. Handfield et al. (2009) and Leenders et al. (2002) point out that in case of just in time deliveries (JIT) this step is often skipped.

Furthermore, the invoice checking and approval of payment, as well as claim settling and enforcing penalty payments are part of this sub-process.

3.2.3.6 Evaluation

After the successful receipt of the order, a supplier evaluation based on the delivery performance should be conducted (van Weele, 2014). This should be carried out based on pre-defined key performance indicators (KPIs) by comparing the targeted performance with the actual performance (Shao, et al., 2008). Accordingly, the supplier rating and subsequently the supplier ranking should be updated, to enable a consideration of the performance for future supplier selection (Fawcett, et al., 2007).

Furthermore, van Weele (2014) mentions the importance of all communicate the results with the supplier to point out improvement potential.

3.3 Summary

The summarizing graph illustrates the considered definition of purchasing as well as the strategic and operative purchasing process with the corresponding tasks.
Purchasing

Definition:
*Purchasing is the actively managing, planning and acquiring the external resources of all internal requirements in the most beneficial way for the company by considering the current and future needs of all internal interfaces.*

Purchasing Process:

**Strategic Purchasing Process**

- Define specifications
  - Determine requirements
  - Define order specification
- Select suppliers
  - Prequalification of supplier
  - RFQ / RFP
  - Analysis of bids
  - Select supplier
- Negotiation & Contracting
  - Negotiation
  - Contracting

**Operative Purchasing Process**

- Ordering
  - Send purchase order
  - Call-off
- Order follow-up
  - Delivery time tracking
  - Trouble shooting
  - Quality inspection
  - Invoice handling
- Evaluation
  - Supplier rating
  - Supplier ranking

*Figure 7: Summary of Purchasing*
4 Frame of Reference

To provide construct validity for the research, a clear operationalization of concepts is provided within this chapter. Further the research model illustrates the tentative formulation of propositions.

4.1 Research Model

The research model presented below illustrates the tentatively assumed propositions following the two research question structure. Firstly, Industry 4.0 influencing variables are shown to influence purchasing, which will be reshaped by the changing setting (see figure 8).

Figure 8: Research Model
## 4.2 Operationalization

The key concepts and considered variables for this research are operationalized in table 5. Further, the own theoretical understanding for ‘Purchasing 4.0’ is created.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Operationalization</th>
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<tbody>
<tr>
<td>Industry 4.0</td>
<td>Industry 4.0 is the industry transformation through digitalization and automation of production and industrial processes in linked supply chains, enabled through internet and future oriented technologies and smart systems (Roblek et al., 2016; Sanders et al., 2016; and Kagermann et al., 2013)</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Industry 4.0 manufacturing within the automotive industry is specified as fully flexible and integrated manufacturing system at the manufacturers’ but also at suppliers’ operations (Stock &amp; Seliger, 2016; Kagermann, et al., 2013).</td>
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<tr>
<td>Integration</td>
<td>Industry 4.0 based integration is divided into vertical integration, horizontal integration and end-to-end integration (Smit, et al., 2016; Kagermann, 2015).</td>
</tr>
<tr>
<td>Business context</td>
<td>Industry 4.0 based contextual changes comprise of changes of products, suppliers, business models and the purchaser role (Roblek, et al., 2016; Pfohl, et al., 2015; Lasi, et al., 2014)</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Purchasing is the actively managing, planning and acquiring the external resources of all internal requirements in the most beneficial way for the company by considering the current and future needs of all internal interfaces (van Weele, 2014; Spina, et al., 2013).</td>
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### Strat. purchasing process:
- Define specification
- Select supplier
- Negotiation and contract agreement

### Oper. purchasing process:
- Ordering
- Order follow-up
- Evaluation

### Purchasing 4.0
Purchasing 4.0 is the highly automatized and digitized managing, planning and acquiring of external resources within an Industry 4.0 environment, enhanced by internet and future-oriented technologies as well as smart systems (own working definition based on references above).

*Table 5: Operationalization of Concepts*
5 Empirical Description

The Empirical Description firstly outlines the different case settings. Additionally, some contextual explanations are provided. More detailed empirical findings for RQ1 and RQ2 can be found in a strongly condensed format in the appendix A.

5.1 Case A

The first case consists of two dyads. The focal point is a German premium car manufacturer. The purchasing context in this case comprises of one type of interior components.

The automotive manufacturer (MA) is located in Germany and produces premium cars characterized by a high number of variants. The purchasing organization is split into product areas, which source components for different car projects. Supplier 1 (S1A) is a multinational corporation specialized on certain interior components. The supplier covers a wide range of different products. Supplier 2 (S2A) is a midsize automotive supplier specialized on natural interior components. The company covers a wider range of value creation within the specialized field. For this case, seven interviews were carried out (see table 6).

<table>
<thead>
<tr>
<th>Organisation</th>
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<tbody>
<tr>
<td>Manufacturer</td>
<td>Management</td>
<td>M1-MA</td>
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<td>Manufacturer</td>
<td>Management</td>
<td>M2-MA</td>
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<td>Manufacturer</td>
<td>Management</td>
<td>M3-MA</td>
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<td>Manufacturer</td>
<td>Purchaser</td>
<td>P1-MA</td>
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<tr>
<td>Manufacturer</td>
<td>Purchaser</td>
<td>P2-MA</td>
</tr>
<tr>
<td>Supplier 1</td>
<td>Sales representative</td>
<td>S1-S1A</td>
</tr>
<tr>
<td>Supplier 2</td>
<td>Sales representative</td>
<td>S1-S2A</td>
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</table>

Table 6: Overview Case Participants Case A

Contextual explanations:

The current state of Industry 4.0 implementations at the focal company is assessed to be comparably high (M1-MA, M2-MA). Several isolated solutions and pilot projects are carried out (M2-MA, P2-MA). From the supplier side, supplier 1 claims to already
promote highly automated, interlinked self-learning operations (S1-S1A). Supplier 2, with a focus on natural resources sees little feasibility for own Industry 4.0 operations (S1-S2A).

Beyond production implementations, participants state that infrastructural changes come along with Industry 4.0 implementations, focusing on digitalization, standardization and automations (M3-MA, M1-MA, S1-S2A). The relevance of Industry 4.0 for purchasing is assessed to be high and even growing (M1-MA, P2-MA). Implementations of Industry 4.0 aspects in purchasing cannot be found yet, while general digitalization is already strongly addressed (M2-MA, S1-S1A).

5.2 Case B

Case B consist of a dyad between a German premium car manufacturer and one of its suppliers for electronical components.

The automotive manufacturer B is located in Germany and produces premium cars characterized by a diversified customer base. The purchasing organization is split into product areas which source components for different car models. The supplier is a Germany-based multinational corporation specialized on electronical components. The supplier covers a wide range of different products, is focused on the automotive industry, and delivers to several different OEMs. Four interviews have been conducted with the automotive manufacturer and two with the supplier (see table 7).

<table>
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<tr>
<th>Organization</th>
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<tr>
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<td>Manufacturer</td>
<td>Management</td>
<td>M2-MB</td>
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<td>Manufacturer</td>
<td>Management</td>
<td>M3-MB</td>
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<td>Purchaser</td>
<td>P1-MB</td>
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<tr>
<td>Supplier</td>
<td>Sales representative</td>
<td>S1-SB</td>
</tr>
<tr>
<td>Supplier</td>
<td>Sales representative</td>
<td>S2-SB</td>
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</tbody>
</table>

*Table 7: Overview Case Participants Case B*
Contextual explanations:

Based on the interview information, the production of manufacturer B can be described as slightly advanced in terms of Industry 4.0. Some machines and production steps are already Industry 4.0 based, while for the majority a replacement or adjustment to comply with Industry 4.0 is planned for the near future. Overall the interview partners confirmed that Industry 4.0 and smart factory are very present topics in their company.

The situation at the supplier was described as similar to the situation at manufacturer B (S1-SB, S2-SB). Nevertheless, it was mentioned that not all production steps can be changed to Industry 4.0 production (S2-SB).

Moreover, the first impact of Industry 4.0 on the purchasing can be observed. As mentioned by one manager at manufacturer B some form of BI-based “personal assistance” for better data availability and data analysis is already initiated. Nevertheless, all interviewees considered the current consideration of Industry 4.0 in purchasing as quite low (M1-MB, S2-SB, P1-MB) or not existing right now (M3-MB).

5.3 Case C

Case C consists of a dyad between the Swedish entity of an international operating construction vehicle manufacturer and one of its suppliers for metal components.

The interview partners at manufacturer C are located in Sweden and responsible for the purchasing for the production within Sweden. Manufacturer C describes itself as low volume manufacturer with, compared to other automotive manufacturers, a small amount of different models. The purchasing organization is split into commodities and consists of strategic commodity buyers, operative buyers, and supplier developers.

The supplier is a Sweden-based multinational corporation specialized on metal components. The supplier covers a wide range of different products and supplies around 25% of its products to the automotive industry.

Three interviews have been conducted with the automotive manufacturer and two with the supplier (see table 8).
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<thead>
<tr>
<th>Organization</th>
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<tbody>
<tr>
<td>Manufacturer</td>
<td>Management</td>
<td>M1-MC</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Purchaser</td>
<td>P1-MC</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Purchaser</td>
<td>P2-MC</td>
</tr>
<tr>
<td>Supplier</td>
<td>Sales representative</td>
<td>S1-SC</td>
</tr>
<tr>
<td>Supplier</td>
<td>Sales representative</td>
<td>S2-SC</td>
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*Table 8: Overview Case Participants Case C*

Contextual explanations:

The conducted interviews revealed that even though Industry 4.0 is a known concept, it is not considered in the production of manufacturer C so far (M1-MC, P1-MC, P2-MC). In general, the production of manufacturer C can be described as quite manual and labor intense (M1-MC). There are also no initiatives towards Industry 4.0 performed right now (M1-MC).

A different situation could be observed at the supplier. Industry 4.0 topics are already considered, even though it is still at a starting point (S1-SC, S2-SC). First initiatives and projects have been started in the production and will consequently increase in the future (S1-SC, S2-SC). Furthermore, a Supply Chain 4.0 initiative was just started recently (S1-SC, S2-SC). Nevertheless, the Supply Chain 4.0 project is focusing more on other industries than the automotive segment in which the project is just starting off (S1-SC, S2-SC).

For the purchasing at manufacturer C, no current influence of Industry 4.0 elements could be identified. This is consistent with the information received from the interviews, that Industry 4.0 is not relevant for the purchasing of their customers yet (S1-SC).
6 Analyzing the Influences of Industry 4.0 on Purchasing

The first research question on “How will industry 4.0 influence purchasing of automotive manufacturers?” is answered for each single case followed by a cross-case analysis, leading towards a generalization of ‘Purchasing 4.0’ for the automotive industry. The single case analysis hereby firstly analyses the causal influences on purchasing followed by a respective analysis of the impact.

6.1 Case A

6.1.1 Causal Influences of Industry 4.0 on Purchasing

All predefined technologies are considered influential by the interviewees, but to different degrees. Three out of four management representatives at the manufacturer describe Cyber-Physical Systems as well as Smart Factories to be rather indirectly influencing purchasing through changes in manufacturing-related areas. The two purchasers confirm this by declaring that the generated data from these technologies will indirectly influence purchasing practices. The Internet of Things as well as Big Data & BI are technologies that are seen to directly and strongly influence the purchasing infrastructure, as all participants agree. Both supplier representatives stress the relevance of real-time data exchange with automotive manufacturers. Further can all technologies be seen as driver for change in manufacturing, integration and business context.

Changes towards Industry 4.0 manufacturing can be expected at the focal company as well as its supplier. The purchasers consider production adjustments to further create causal effects on influencing categories, but are expected to have little direct influence on purchasing. Especially the management believes, that manufacturing adjustments will strongly support integration on a vertical but also horizontal level, as highly linked operations offer the required frame for integration throughout all levels and all actors within the supply chain. The supplier representatives confirm the influence on horizontal integration. Manufacturing changes further influence products, as new types of machines and systems need to be sourced. These changes can also influence the context in terms of suppliers, as holistic interconnections require proper interfaces and operation set-ups at the supplier’s side as well.
Integration on a vertical level can be described to directly influence purchasing in terms of structure. According to a supplier representative, closer integrations will imply moving from functional isolations to process-oriented structures. The management at the manufacturer confirms this development, describing the required structure as cross-functional purchasing project islands. The purchaser primarily see this structural integration to come with an integration of IT systems, influencing the purchasing infrastructure. The horizontal integration will further shape the infrastructure and collaboration, as systems will be required to be stronger integrated with suppliers. In this regard, the management and supplier representatives call for a collaboration platform. While most participants state the high relevance of closer horizontal integration, both supplier representatives consider the feasibility of actual end-to-end integration as low.

The business context is not only highly affected by all influential categories but further strongly influences purchasing itself. Not only will new production equipment be required but technologies will also become part of the product. The management at the manufacturers declares, that ‘Smart Products’ need to be offered to the customer. Through integration of sensors and computation into formerly regular products, the purchasing scope will be changed drastically. A supplier representative in this regard remarks that not all components will be effected, as classical products remain largely unaffected (S1-S2A). The management at the manufacturer and a supplier representative state that through the increased production capabilities, individualization requirements of customers can increasingly be offered. This further influences the scope towards even higher variation complexity.

Technological advancements as well as corresponding product changes further influence the scope in terms of supplier base. Suppliers, that offer the required maturity in their operations and can serve the increasing demand for innovation need to be reached and integrated into current structures and processes. The management at the manufacturer explains that these suppliers will most likely deviate strongly from traditional suppliers.

Industry 4.0 technologies create entire new business models based on created customer data but also generated data during production with sensor-equipped machines. This further enlarges the scope of purchasing as data exchange agreements will be required.
Further, tendencies towards shared innovations imply stronger collaboration, as the management agrees. Business models are further seen to be changing when it comes to licensing of software/application, agree purchasers and the management. A supplier representative deduces, that through CPS cost allocations in production become highly precise, enabling new business models based on parameter prices and volume agreements instead of classical product calculations (S1-S2A).

Most participants state, that impacted by the described factors, the purchaser role will change drastically, further influencing purchasing. Advanced system support, stronger collaboration with other functions as well as collaboration with suppliers will influence the purchasing scope, as the purchaser role becomes more strategic and analytical.

6.1.2 Analysis of Impacts of the Influences through Industry 4.0

Based on the causal influences, the impact can be described to change purchasing. To create a transition to RQ2 the authors classified the impacts into purchasing scope, structure, infrastructure and collaboration evolved from the empirical data. These categories are applied for all cases to further provide a foundation for the following cross-case analysis.

6.1.2.1 Scope

Obviously, production-related equipment in an Industry 4.0 environment creates new product categories that need to be purchased (Kagermann, et al., 2013). More interestingly the interviews revealed, that there will also be a change in current component purchasing of direct production material. According to the management at the manufacturer, developments towards ‘smart cars’ include development of ‘smart components’, expanding current components to further include sensors, processors, actuators as well as software. This means that technological parts will increasingly be integrated in most components/modules that are purchased.

Along with production advancements come customer expectations towards feasibility of highly customized and individualized products (Lasi, et al., 2014). For the purchasers, this high individualization basically leads to single purchase orders for each customer, increasing the variant complexity exponentially. This also results in adjusted requirements for costing as negotiations on the individual component level are not feasible (S1-S2A).
Moving towards Industry 4.0 must not be seen as an isolated implementation at one’s operations. To truly benefit from its potential, a holistic approach needs to be promoted (Stock & Seliger, 2016). This means, that suppliers need to follow the development by implementing Industry 4.0 applications within their operations, at least at the interface between sales/production planning towards the manufacturer (Schlechtendahl, et al., 2015). The interviews revealed, that not all traditional suppliers along the supply chain will be capable of providing these requirements (S1-S2A, S1-S1A). Further, suppliers that can offer technological innovations promoting ‘smart products’ are not necessarily acting within the automotive industry or might still be in very early business stages like start-ups. These innovation suppliers need to be explored, attracted and integrated into the supply chain, creating a new set of suppliers, further leading to new challenges. As pointed out by M2-MA, new technology suppliers will not be operating in low-labor-cost countries but rather be found in innovation clusters like Silicon Valley. A general re-shoring/near-shoring tendency will therefore influence purchasing and supply chain strategies (Stock & Seliger, 2016).

Based on sensor technologies, entirely new business models can be imagined (M2-MA, M3-MA). The generated data from sensors in the final product, the car, as well as the generated data from machines during the production represent a value (Kagermann, et al., 2013). To whom the data belongs, how data is used or shared and how access to information is compensated consequently need to be part of the agreements between purchaser and supplier.

Considering the influences from a changed purchaser role, the purchasing function will undergo a strong shift towards a strategic focus. With stronger system support and automations, administrative tasks are reduced. The management and purchasers agree, that the purchasing scope will correspondingly include more analytical and decision related activities. Under consideration of changing structures and closer collaborations, the responsibility for managing interfaces will increasingly engage purchasers.

6.1.2.2 Structure

Along with vertical integration come changes in organizational structure. Closer integration hereby enables a stronger process-view, considering all process partners (developers, quality managers, logisticians and purchasers). A beneficial structure in this case can be described as temporary project island (M2-MA, S1-S2A). In this type
of structure, all functions are closely collaborating and co-creating. A high focus is set on the early phase to allow development under consideration of all relevant perspectives, while decreasing cycle times (P1-MA). This more process-oriented and holistic organizational structure is described to further allow a more holistic decision making, in which aspects like logistical complexity, quality advantages, and development competencies can be quantified and considered, to base nominations on actual real costs (S1-S2A). Goal achievement based on project measures instead of functional measures hereby can allow goal alignment between the process partners.

The horizontal end-to-end integration further influences the organizational structure in form of reducing company boarders. The big picture, which can be drawn here is a tendency towards end-to-end engineering, consequently a closer collaboration in development (Stock & Seliger, 2016; Kagermann, et al., 2013; Knight, et al., 2016). Nevertheless, the feasibility of actual end-to-end integration is assessed low (S1-S2A, S1-S1A).

Influenced through increased data quality from production units, closer integration and respectively higher transparency, a new form of cost negotiations needs to be considered. While cost engineering and detailed cost break downs are already used, this can be brought to an entire new level (M3-MA, S1-S2A). Considering the increasing individualization and corresponding complexity in product variants, the focal point of price agreements needs to be shifted from product level to parameter or axiom level (S1-S2A).

6.1.2.3 Infrastructure

All participants agree, that based on the technological advancements and closer integration purchasing will be facing an entirely new level of information access and quality. Real-time data from the own production, suppliers’ operation but also data on locations will be relevant for purchasing. This integration of interfaces is further seen to take place between the sales and purchasing interface. Consequently, B2B platforms that allow documentation and data sharing need to evolve towards supplier collaboration platforms.

The required network structure for exchange and application of data hereby is provided through the IoT (Kang, et al., 2016). Beyond this exchange, Big Data & BI offer the
potential to structure and use historical data from different functions within the company (Zhou, et al., 2015). Further can supportive internet data, such as public information on suppliers or meteorological data, be integrated.

All this data by itself is of little use to purchasing, as no human being can be expected to consider all that information (P1-MA, P2-MA). Business Intelligence and smart algorithms here come into play. Therefore, the infrastructure is ought to provide structuring, prioritizing, analyzing and even predictions based on the mass of information.

The big picture behind these changes can be seen as a holistic and integrated IT platform that directly links internal function but also suppliers.

6.1.2.4 Collaboration

Internal integration of functions implies changes in collaboration, that need to be managed. The collaboration can be described as co-creation starting already in the development stage. This is expected to be orchestrated by the purchasing function (M2-MA, P1-MA, P2-MA).

Collaboration on the horizontal level will go beyond close collaboration with the direct suppliers to be expanded through the entire supply chain. Innovations and development will increasingly be carried out in collaboration with tendencies towards open innovations. Even on the operative level, technologies and integration enable collaborative planning down to the actual production planning, that can be carried out simultaneously (Kagermann, et al., 2011).

Concerning new supplier, the form of collaboration also changes. Different forms of suppliers do not only need to be considered in terms of interactions and compliance but it can also be imagined to purchase rather early stage ideas that are further developed in collaboration.

One manager and a supplier representative pointed out, that through a deep integration of production planning and interacting automated systems, a new business model can be imagined. Instead of purchasing components from suppliers, a more flexible approach of purchasing capacities within a production facility is possible. In this case, purchaser and supplier would define precise cost agreements on materials and parameter with consideration of required capacities (P1-MA, P2-MA). This would represent a rather
pure form of an extended workbench (highly interdependent supplier-buyer relationship), in which production planning at suppliers is automatically deduced from production planning at the OEMs (Leppelt, 2014). While technological this seems feasible through integrated smart factories, actual implementation is strongly limited through the common concept of customer independent operation set-ups at supplier operations (S1-S1A, S1-S2A). Business models will also change in terms of contract agreements. Here, agreements are imagined to have less of a traditional buying character shifting towards licensing (M2-MA, P1-MA). Collaboration can also bring the potential off offering direct negotiation feedback to suppliers already during the RFQ phase (P1-MA, P2-MA).

6.2 Case B

6.2.1 Causal Influences of Industry 4.0 on Purchasing

Considering the four predefined Industry 4.0 technologies, only three of them could be identified during the interviews: CPS, IoT, Big Data/BI. All interview partners did not consider Smart Factories to have any direct influence on purchasing. Furthermore, while for IoT and Big Data/BI a direct influence was identified in all interviews, CPS was considered to have a rather indirect influence. Through IoT the purchasing infrastructure as well as the internal and external collaboration are directly influenced while Big Data and Business Intelligence only influence the infrastructure.

Manager and purchaser agree, that CPS is indirectly influencing purchasing as it is changing manufacturing and those changes in the manufacturing respectively influence purchasing. Besides manufacturing, CPS also influences the business context as it leads to new smart products, which consequently have an influence on purchasing.

The implementation of Industry 4.0 in manufacturing also has influence on purchasing. While from the manufacturer’s as well as from the supplier’s perspective a huge impact from Industry 4.0 implications in the suppliers’ production is expected, only a minor influence on purchasing is considered from the own production. Based on Industry 4.0 driven own production, one manager expects a change towards demand driven production, which will change the purchasing scope. Besides that, Industry 4.0 based production will only influence purchasing based on integration. The presence of Industry 4.0 in manufacturing alone brings no change to purchasing, but if a system
integration between purchasing and the own production as well as the suppliers’ production exist, this has an influence on purchasing.

Vertical integration will influence the purchasing infrastructure by providing an improved internal system connection with reduced system interruptions as pointed out by all managers. Furthermore, two managers and the purchaser expect that closer collaboration between the different functions will be supported. On the horizontal level, all interviewees expect a closer integration between suppliers and manufacturers. This will also lead to a changed infrastructure and closer collaboration. The infrastructure will further change due to system integration and automated processes with suppliers. This also influences the collaboration as it provides both parties with improved data and eases communication.

Even though an influence of both vertical and horizontal integration is expected, the influence of vertical integration is expected by all manufacturer representatives to be less impacting than the influence of horizontal integration.

Due to new products and suppliers, an adjusted price basis as well as shifting the purchaser role, the purchasing scope will change. According to two managers, new products in form of smart and technological advanced products will come into the focus. Consequently, the supplier base will change and respectively the purchasing scope. Due to technical support and increased flexibility, one manager and one sales representative see a development towards parameter-based pricing instead of the current product-based pricing. This leads to a change in the way of business with suppliers. Furthermore, all interviewees agreed, that the enhanced usage of technologies will also influence the role of the purchaser towards a more strategic focus with reduced administrative effort which sets a new scope.

6.2.2 Analysis of Impacts of the Influences through Industry 4.0

Based on the causal influences, the impact can be described to change the purchasing scope, infrastructure and collaboration.

6.2.2.1 Scope

The increasing relevance of Industry 4.0 will shape the scope of purchasing. First of all, this will be the case due to customer demand for new, smart products, software and technological elements such as sensors, which was pointed out by two managers.
Dealing with digital products in a lot of cases also means short product life cycles due to the fast changing technology. In these cases, a higher flexibility will be required. In this regard model life span contracts of five to seven years will not be suitable anymore. New and flexible solutions need to be developed to allow up-to-date products and software in the cars.

As pointed out by M1-MB and M3-MB during the interviews, new suppliers in form of technology companies and start-ups are increasingly considered. Right now, the supplier base can be described as quite automotive focused and dependent on this industry, leading to a strong negotiation power of the manufacturer. This will change in case of dealing with technology companies that are less dependent on the automotive industry and might have larger customers than the automotive manufacturers. This means new strategies and cooperation models need to be.

To work with start-ups, new processes and business models need to be created. Due to the nature of start-ups shorter and more flexible processes are required. A currently common timespan of 16 months from receiving of specification until start of production, as pointed out by M2-MB and M3-MB, will not be feasible for start-ups. Furthermore, for huge orders of automotive companies, the financial situation of start-ups might not be suitable, therefore investment and financing models need to be created.

Increasing flexibility is also required due to manufacturing changes. Industry 4.0 in the production will lead to a demand driven production, as pointed out in the theory by Kagermann et al. (2011) as well as in the interview with M1-MB. This means that flexible suppliers are required which can react to fluctuating quantities and flexible ordering behavior. Furthermore, a more flexible ordering at the manufacturer is required which increases the complexity and the planning effort.

The purchasing scope will also be influenced through the appearance of a new, parameter-based pricing that is seen as beneficial by M1-MB and enabled through Industry 4.0 technologies. Through a more transparent production process in combination with a smart system that is able to deal with huge amounts of data, costs can be determined for each factor involved in the final price. Consequently, prices can be agreed on a parameter level, considering costs for a certain task, raw material, or other influencing factors. Based on that, the final price for all different products
supplied by the respective supplier can be provided. This respectively leads to a different way of dealing with purchasing and the suppliers.

Furthermore, all interviewees agree that the purchasing function will change towards a more strategic oriented one. Operative tasks will be highly automated and administrative tasks reduced due to automation and system support. This will help the purchaser to focus on the core tasks and lead to better decisions. Furthermore, it will also reduce workforce for administrative and basic tasks such as data maintenance and processing.

This change in the purchasing scope will not only lead to positive effects, but also creates challenges the company has to deal with. Skilled employees need to be found, that can handle the new requirements of a purchaser, existing employees need to be trained to cope with the new setting, and solutions need to be found for those employees that are obsolete due to automation of their tasks. As this change process takes a while, it is important that companies already start with it right away.

Overall, it can be said that the scope of purchasing will be influenced by several challenges. New suppliers need to be handled as well as increasing flexibility which requires changes of the existing structures and behaviors.

6.2.2.2 Infrastructure

The implementation of advanced technology in purchasing will provide easier access to data. This data will be generated from the own system, the own production, the suppliers’ productions or the internet. Through CPS and IoT, purchasing can get access to corresponding real-time information. This increase in transparency leads to a reduced uncertainty (Hermann, et al., 2016). Through direct access to production information of the supplier, the manufacturer can track delivery statuses and identify production interruptions in an early stage. Furthermore, uncertainty can be reduced by infrastructure changes due to automatic collection of supplier news or natural disaster forecasts.

Based on this information and with help of Big Data and Business Intelligence, alternative solutions can be developed and evaluated to avoid production interruptions and allow a stable supply (Kang, et al., 2016). This was considered as very relevant by two managers and the purchaser.
Another data analysis advantage in this regard is the collection of huge amounts of data in the system and smart analysis of this by BI, negotiation patterns can be identified, and suppliers evaluated in a more holistic way. Furthermore, one sales representative and a manager state that real time access to suppliers’ capacities can help to easier decide on short term volume changes.

All interviewees considered in some way increased automation as well as removal of system interruptions to lead to reduction of administrative tasks and speed up processes. Furthermore, improved internal and external communication through an enhanced infrastructure will also speed up processes.

This means the changes in the infrastructure will lead to better decision making, reduced uncertainty, less administrative tasks, and faster processes.

### 6.2.2.3 Collaboration

Based on the changes in technologies, one sales representative and two representatives of the manufacturer expect a closer collaboration. This can be explained by the fact, that new technologies will make collaboration easier. As closer collaboration is desired by the interview partners, it can be expected that the potential that evolves will also be made use of. Easier communication, exchange of information, and access to data on the supplier as well as the manufacturer side will positively contribute to that. This will lead to process optimizations and cost savings. Cost savings can be created through a more transparent and interactive joint product development, which allows the easier consideration and comparison of different options, as well as the easy exchange of possible changes to optimize costs. It will also speed up the development process as well as the following offering process. Furthermore, through better access to data and information, supplier and manufacturer have a better overview, which allows for improved planning and reduced costs. This was pointed out as beneficial by S1-SB as well as M3-MB.

Additionally, one supplier representative as well as three manufacturer representatives point out that a more transparent process can help to jointly identify unnecessary or redundant tasks.

Nevertheless, the interviews with the sales representatives also showed that to achieve closer collaboration a win-win situation for both sides need to be considered to assure
suppliers willingness for closer collaboration. Therefore, concepts that are beneficial for both sides need to be developed and an agreement about sharing of benefits should be part of all initiatives of closer collaboration.

Furthermore, it should be noticed that closer collaboration will also increase complexity as more interlinkages and system connections exist, as mentioned by M1-MB as well as in the theory (Oesterreich & Teuteberg, 2016). Therefore, an infrastructure that is able to manage this complexity is required.

A concept frequently referred to in relation to collaboration is supply chain wide integration and collaboration (Stock & Seliger, 2016; Kagermann, et al., 2011). Nevertheless, the interviews showed that a change towards this due to new technologies is not very likely. According to three interview partners, the 2nd and 3rd tier suppliers will, due to the huge complexity created by several different customers and standards, lacking skills and knowledge, and high investments not be possible. Therefore, Industry 4.0 will improve the supplier-manufacturer collaboration but is not likely to help to utilize the full potential of collaboration.

6.3 Case C

6.3.1 Causal Influences of Industry 4.0 on Purchasing

Considering the gathered information from the interviews, all four fundamental technologies are considered as influential, even though to a different extent. While the main influence can be seen through IoT and Big Data/BI, less influence was identified for CPS and only a small influence for smart factories. While all participants considered an influence through IoT and Big data/BI, three participants (one at supplier, two at manufacturer) mentioned an influence through CPS, while only one purchaser considered an influence through smart factories. This is the case, as no CPSs are expected to be present in purchasing, but the general presence of CPS in other functions will have influence on purchasing. Therefore, an indirect influence of CPS and Smart Factories through manufacturing can be identified. IoT is directly influencing the infrastructure and collaboration by enabling interfaces and joint platforms. Big Data and BI only have a direct influence on the infrastructure based on increased data collection and analysis.
As the interview partners at manufacturer C pointed out, Industry 4.0 is currently not considered in their production and no initiatives are planned, there is no indication of the own manufacturing as influencing factor on purchasing.

With respect to the influence of Industry 4.0 in the production of the supplier, one purchaser and one supplier representative, consider an influence on purchasing. This influence is based on better data access to production related information at the supplier. As this only applies in case of system integration between the supplier and manufacturer, there exist no direct influence on purchasing but an indirect through integration.

Integration can be described as influencing purchasing on a vertical as well as horizontal level. The interviews revealed that a stronger influence is expected through horizontal integration than vertical integration. Vertical integration is expected to have a direct influence on infrastructure as well as collaboration. Through technology driven internal system integration the purchasing structure changes towards a more holistic system. Furthermore, a closer collaboration results from this with respect to joint development through easier purchasing involvement, as pointed out by P2-MC. On the horizontal level the influence mentioned by all interview participants is a closer collaboration between the manufacturer and the supplier. This is the case in form of joint development, as well as improved communication and information exchange.

Furthermore, one sales representative and one purchaser pointed out that through horizontal system integration the infrastructure will change, similar as for the vertical integration, to a more holistic and joint system with increased interfaces.

There is only a minor change in business context expected for manufacturer C. This is the case as by all interviewees at manufacturer C new suppliers as well as new business models are considered to be little relevant. Furthermore, an influence through new suppliers is only mentioned by one purchaser in form of changes towards 3D printing of components for serial production. This respectively will influence the purchasing scope. Another influence on the purchasing scope which was seen by all interviewees is the purchaser role. This will be the case through less administrative tasks, an automated operative process, and an increasing strategic focus.
6.3.2  Analysis of Impacts of the Influences through Industry 4.0

Based on the causal influences, the impact can be described to change the purchasing scope, infrastructure and collaboration.

6.3.2.1  Scope

With respect to manufacturer C, the scope of purchasing will change through several aspects. First of all, one purchaser at manufacturer C considers new suppliers in form of 3D printing suppliers to occur through Industry 4.0. This will lead to the challenge of identifying new suppliers as well as adapting to new structures, processes and ways of doing business.

Furthermore, all interviewees expected a change of the purchasers’ role towards a more strategic orientation and less administrative work. One purchaser and the sales representative at the supplier also expect a highly automated operative purchasing process. This leads to changed skill requirements of purchasers, the reduction of workforce or the change of responsibility towards more strategic tasks.

Another impact of Industry 4.0 will be a changed pricing and costing structure as mentioned by all interview partners at manufacturer C. Through new technologies and improved system support, price structures based on predefined parameters will be possible and respectively will change the focus of purchasing from a single product focus to a broader view. Moreover, prices for individual products can be determined faster and less negotiations are required, which will speed up the purchasing process and enables the better comparison of design alternatives.

6.3.2.2  Infrastructure

The biggest influence of Industry 4.0 on the purchasing infrastructure can be identified in terms of removal of system interruptions and interfaces with involved actors. This is expected as beneficial by both, the manufacturer as well as the supplier. Through CPS, IoT, and BI the automatic transfer of information and availability for every involved actor, system interruptions can be reduced as well as data quality and access increased (Kagermann, 2015). This results in less administrative effort and transferring mistakes, as less information need to be entered into the system manually or transferred from one system to another. Furthermore, the increased transparency and faster access to information leads to improved decision making, better planning, reduced risk and faster
processes. As pointed out by a sales representative, improved transparency does not only lead to advantages at the manufacturer side but also leads to reduced inventory, better planning, and reduced costs at the supplier side. Consequently, the automotive manufacturer can also benefit from lower purchasing prices.

Furthermore, joint interfaces between the manufacturer and the supplier but also between different internal actors can be enabled through IoT. This is especially relevant for the product development process as pointed out by all three interview participants at manufacturer C. Through a joint interface for the product development, every actor is provided with the same information and can directly provide input. This results in a speed up of the process due to less changes, faster availability and exchange of information, as well as reduced costs through early identification of cost drivers.

The creation of system interfaces between different actors, internal and external, as well as reduction of system interruptions lays the foundation to an increased automation of tasks and processes. This was especially in focus and seen as beneficial by the sales representative as well as the purchasers.

The influence of new technologies also leads to an improved system support for analysis of data. While through IoT and Big Data the amount and quality of the collected data is increased, BI enables a smart and automated analysis of this data (Kang, et al., 2016). As pointed out by P1-MC e.g. cost breakdowns could be analysed and compared for different suppliers by making use of such a system assistance.

6.3.2.3 Collaboration

The influence of new technologies will lead to a closer internal and external collaboration. As pointed out by both purchasers, there is a desire for closer collaboration in product development with respect to purchasing and suppliers. Therefore, based on the before mentioned occurrence of joint platforms and interfaces, a closer collaboration for product development is enabled. This allows the same time access to information and an improved exchange of ideas. Consequently, costs can be reduced and the planning process accelerated. Furthermore, closer collaboration will be created in form of a more holistic view and exchange of information. This allows, according to S1-SC more collaboration with respect to planning at the supplier and manufacturer side and respectively reduces costs and administrative effort.
Furthermore, a better understanding of each others processes, as pointed out by P1-MC, enables the manufacturer as well as the supplier to optimize specifications and processes in the most beneficial way for both parties. This closer collaboration and the hereof resulting advantages are only possible through the support of technologies such as IoT and CPS and the respective closer vertical and horizontal integration.

6.4 Cross-Case Analysis

To argue on generalizabilities, purchasing experts from consultancies and institutes are further included in the cross-case analysis (see table 9).

<table>
<thead>
<tr>
<th>Organization</th>
<th>Perspective</th>
<th>Reference code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultancy</td>
<td>Expert</td>
<td>E1</td>
</tr>
<tr>
<td>Consultancy</td>
<td>Expert</td>
<td>E2</td>
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<tr>
<td>Institute</td>
<td>Expert</td>
<td>E3</td>
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<td>E4</td>
</tr>
<tr>
<td>Consultancy</td>
<td>Expert</td>
<td>E5</td>
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</tbody>
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Table 9: Overview of Supporting Experts

6.4.1 Discussion on Causal Influences of Industry 4.0

Technology:

Considering the technological influence through Industry 4.0, a quite homogenous picture can be drawn from the three considered cases. The rather complex structure of causal influences is hereby illustrated in figure 9 at the end of this sub chapter.

Regarding Big Data & BI all cases see a clear direct influence on the purchasing infrastructure. Also throughout all considered functional perspectives, the influence is assumed to be very strong. IoT technologies are further considered to directly influence the purchasing infrastructure and collaboration. The influence can hereby be described as foundation for new linkages and corresponding applications. In all cases, the influence of CPS is considered an indirect one. CPS hereby are seen to strongly influence manufacturing, ultimately influencing the business context. The same statement can be formed concerning smart factories, which are considered to have little indirect influence. In case B, smart factories were not discussed, which can only be
explained through the semi-structured interview approach. Experts in this regard confirm the stated little indirect influence (E4, E3).

Consequently, the direct technological influence can be summarized to be limited to origin in Big Data & BI and IoT with influences on infrastructure and collaboration.

**Manufacturing:**

Concerning manufacturing influences, a general pattern can be found while few differences need to be discussed.

Concerning the influence through own Industry 4.0 manufacturing adjustments, both cases originating in the car industry present an indirect influence on purchasing through changes in vertical and horizontal integration. Case C, which originates in a different sector of the industry does not show clear tendencies towards Industry 4.0 manufacturing at own operations, not allowing any further deductions on the influence. Case B further presents an interesting direct influence on the purchasing scope based on demand driven production, affecting supplier/ordering requirements. This direct influence is also described by a purchasing expert (E2). In regard to the manufacturing changes at the supplier side, all cases present evidence, that purchasing will indirectly be influenced through stronger horizontal integration.

In conclusion, the influence of manufacturing can be described as an indirect one through effects on the vertical and horizontal integration, as well as a direct one on the scope in terms of changed supplier/order requirements.

**Integration:**

The causal influences of integration on purchasing are strongly conform within the cases, basically only varying in terms of expected strength.

Referring to the vertical integration, all cases show a clear influence on the purchasing infrastructure. While case B and C further identify a direct influence on the purchasing collaboration (internal), case A goes beyond this. In case A, vertical integration is expected to result in new purchasing structures, forming project islands instead of collaborating functional departments. This rather radical shift is also expected by a purchasing expert (E3). When it comes to the influence of horizontal integration, all cases indicate that a direct influence on the purchasing infrastructure and collaboration
exists. This can be explained through data access and collaboration potentials through interlinked systems.

Concluding, it can be stated, that integration will directly influence the purchasing structure, infrastructure and collaboration.

*Business context:*

The business context factor represents a category, through which most indirectly influencing factors are effecting purchasing in some form. Here a high conformity within the case is generated.

Regarding the influence of new ‘smart products’, case A and B indicate a direct influence on the purchasing scope, as the purchasing portfolio will change. A similar picture is created referring to changing suppliers. Here a direct influence on the purchasing scope is found even in all cases based on the need for digitalized innovation suppliers or changing production practices. Business models further create a direct influence on the purchasing scope. In case A, the purchasing collaboration further is influenced as new business models (e.g. shared innovations) influence collaboration with suppliers. This influence on purchasing collaboration is confirmed by a purchasing expert (E1). The purchaser role in all cases is assessed to become more strategic and analytic, directly influencing the purchasing scope.

This results in a direct influence on purchasing scope and collaboration through the changing business context.

*Illustrating the causal influences of Industry 4.0 on purchasing:*

Figure 9 illustrates all described indirect and direct influences, that can be generalized throughout the cases with confirmations of experts.
6.4.2 Discussion on Impact through Influences of Industry 4.0

The before-mentioned causal influences create a perceptible impact which is derived below.

6.4.2.1 Scope

Innovative, digitalized, individualized and fast changing components:

Deduced from case A and B, new products will create major changes for the purchasing scope. ‘Smart’ products will change from foremost non-electronical components into innovative electronical enhanced components. Further, electronical products will become more complex and strongly linked to respective software solutions. Case A, strongly based on interior purchasing, further indicates the tendency towards higher individualization and customization. This tendency was confirmed by an industry expert but needs to be limited to certain product areas (E5).

Consequently, the purchasing portfolio for purchasers will be extended, requiring more expertise. Innovative, digital products hereby come with shorter life cycles and a massive complexity in terms of variants, also influencing the time span of delivery agreements. The change in products further amplifies supplier changes discussed below.

While these findings can be generalized for the premium car sector (case A & B),
special sectors like the one of construction vehicles (case C) are hereby not expected to see this drastic change in components as product individualizations are less common.

*New suppliers and developed supplier base:*

According to case A and B, to deliver innovative digitalized products, new suppliers need to be explored, attracted and included into the supplier base. These suppliers do not necessarily have an automotive focus and might still be in an early business phase (e.g. start-ups). Case C on the other side centers around new production capabilities such as 3D printing. In all cases, it became obvious, that supplier enhancements towards Industry 4.0 and, respective improved flexibility, need to be triggered by the manufacturer, calling for a development of the existing supplier base.

These changes in the supplier base result in a need for structural and processual adjustments to consider new suppliers in an environment with different power structures. These suppliers are further located differently due to less need for low-labour-cost strategies. While these influences can be mostly generalized for the automotive industry, the origins for car manufacturers are rather customer-oriented or product-based, whereas influences at highly specialized (construction vehicles) manufacturer are production driven.

*Strategic and analytical purchaser role:*

Throughout all cases it is stated, that the purchaser role or function will increasingly focus on strategic tasks like analyzing and decision making. This is explained through a stronger IT-support, and automation of operative activities which reduces administrative tasks.

Consequently, freed resources can be used to improve strategy development and support co-creation as internal and external interface manager. This tendency is not just seen by all case participants but further confirmed to go beyond industry boarders as a general influence of Industry 4.0 on purchasing (E1, E3).

*Data as business:*

Case A presents a consequence, that comes with changed products and machines in an Industry 4.0 environment. This change can be described as ‘data as business’. Based on processed sensor data from smart products and smart machines, data will be accessible, which can be distributed in the supply chain.
Consequently, data owning agreements will become part of the purchaser-sales interface, provide the purchaser with a leverage point through data access.

While this factor was mostly stressed in case A, experts see a high relevance for the entire industry (E3). Nevertheless, this influence cannot be generalized as all other participants see this influence to be beyond the purchasing scope.

*Parameter and capacity costing:*

All cases clearly show a new approach for costing through Industry 4.0. Higher data transparency and CPS interlinkage will enable a new form of cost allocations, that changes cost and contract negotiations. Simplified, this comes with a change from product-centered negotiations to parameter-centered agreements. This means, that relevant parameters or axioms are considered, which in different combinations can represent all potential product variants.

As a result, purchasers and sales representatives will be able to negotiate costs for production parameters and capacities compared to traditional negotiations on products/components. This change in costing can be found in all cases and is further expected to occur by an interviewed expert (E2).

### 6.4.2.2 Structure

*Co-creation through process-oriented project islands:*

While case B and C just call for closer internal (vertical) integration, case A offers a more extreme solution to the need for closer internal collaboration. In a form of project islands, all required functions are collaborating intensely in an own project structure.

Even though this aspect is based on only one case, expert opinions imply the usefulness of this structure, which is already tested in other automotive companies (E4, E3).

### 6.4.2.3 Infrastructure

*Holistic networks:*

All cases indicate the necessity of holistic networks for Purchasing 4.0. Based on IoT an external and internal linked network is required. This network would result in direct access to all relevant historical and cross-functional data from different functions, as well as supplier data. Beyond that, the integration of public internet data such as
financial reports or geographical and meteorological information are assessed to be important.

While this very holistic network is especially crucial for case A and B with higher complexity in terms of product variants and supplier, this factor can be generalized for the industry (E5)

*Collaboration platforms:*

One big change through Industry 4.0 are collaboration platforms. Real-time, high quality data usage through integrated interfaces is a demand found in all cases. A collaboration platform with integration of own and suppliers’ operations but also the sales function of suppliers is seen to influence strategic and operative purchasing interactions as transparency is improved.

As this change is represented in all cases, it can be generalized for the automotive industry.

*Assisting Systems:*

Beyond networks and platforms, systems are expected to become smarter based on the underlying structure and Big Data and BI capabilities. This development is considered highly important as complexity in the industry is ever-increasing. As a result, the system will assist the purchasers in data structuring, prioritizations, analyzing and even create simulations and predictions for strategic and operative purposes. For the purchaser, therefore decision making is improved while uncertainty and administrative task reductions allow faster process times.

This finding is represented in all cases, allowing a generalization for the automotive industry.

**6.4.2.4 Collaboration**

*Cross-functional integration:*

Internal cross-functional integration is considered important in all cases. While case A shows an extreme form (see chapter 6.4.2.2) case B and C represent a form of stronger joint development. This means that co-creation will increase internally, improving functional goal alignment as isolated early development stages are reduced.
A stronger internal cross-functional integration can be found in all cases, allowing a generalization for the automotive industry. Differences might exist in the extent of collaboration.

**Approximating end-to-end engineering:**

End-to-end engineering, the inclusion of suppliers and sub suppliers in the development, is in all cases a promising vision. Surprisingly, indications from the supplier representatives at case A and B indicate little feasibility for a total end-to-end engineering as n-tier suppliers often do not have the required structures, resources or know-how. Consequently, the integration and joint engineering will further increase, while a stepwise deeper integration of firstly 2nd tier suppliers in the development and engineering process is only possible in particular cases.

Experts expect the tendency towards end-to-end engineering as generalizable even beyond the automotive industry (E3). According to the cases, the generalizability for automotive purchasing is rather low, as many supply chains neither possess the required setting nor can a common desire of all parties be identified.

**Interactive planning:**

While the collaboration in development and strategic matters is increasing through Industry 4.0, the operative level can become more interactive in the supply chain. Case A presents a tendency towards an extended workbench that can be claimed to be derived from the demand driven production and new costing/contracting. A result of this would be the highly interactive production planning, derived from the manufacturer, that transfers real-time, highly fragmented component call-offs from suppliers’ productions’ in accordance with corresponding capacity agreements. Experts share this tendency towards highly interlinked planning (E2, E4)

**Co-optimizations:**

A further aspect influencing purchasing collaboration can be described as co-optimizations. Based on the underlying changes in infrastructure, automated feedback can be provided to the sales interface. Consequently, sales representatives can receive direct feedback on bidding performance, based on internal best practice calculations and bids or competitors.
These forms of collaborative data usage are also expected by the interviewed experts (E3, E1)

6.4.3 Summarizing Purchasing 4.0 in the Automotive Industry

Combing the different influences on scope, collaboration, structure and infrastructure a Purchasing 4.0 setting for the automotive industry can be deducted. Figure 10 hereby illustrates the key changes that were translated from the influence of Industry 4.0 into comprehensive changes. As the automotive industry encompasses several different sectors, generalization hereby, to some extent, needs to be restricted. One key finding in this regard is, that individualization is strongly consumer driven and therefore not generalizable to the construction vehicle sector. Furthermore, data as business needs to be excluded from generalizations, as it goes beyond the considered purchasing scope. Furthermore, the approximation of end-to-end engineering was found to be highly purchasing context bound.

![Figure 10: Purchasing 4.0 in the Automotive Industry](image-url)
7 Analyzing the Reshaped Purchasing Process

In this chapter, the second research question on “How will Purchasing 4.0 reshape the purchasing process of automotive manufacturers?” is answered for each case, followed by a cross-case analysis. Within the cross-case analysis, a final visionary model for a ‘smart purchasing process’ is created.

7.1 Case A

7.1.1 Strategic Purchasing Process

Based on the interview responses and RQ1, the relevance and potential for adjustments in the strategic purchasing process is assessed high and comes with several general changes. The organizational structure around the entire strategic purchasing process is expected to change fundamentally. Former isolated structures are seen to be closer integrated towards project islands, in which all related functions collaborate. Further, the sequencing of the sub-processes will change. This is not just the case as shorter cycles need to be realized but also required as sub processes merge due to closer integrations.

These changes are expected to occur supported by an integrated holistic IT-system, that interlinks all related internal functions as well as the corresponding suppliers.

7.1.1.1 Define Specification

The first strategic sub process of ‘define specifications’ in Purchasing 4.0 is shaped by the key requirements of improved internal and external collaboration, or more precisely co-creation, as well as the need for shorter cycles (M2-MA, P1-MA).

The top management describes, that the determination of requirements will shift from former rather isolated requirements by the consuming department towards a holistic process view. This means that designers, developers, quality managers, logisticians as well as purchasers need to co-create the requirements in an adjusted form of organizational structures that could be described as project islands.

When deducing specifications from the collaboratively developed requirements, the integration of external partners along the entire chain will follow. In this case, not just the direct suppliers but all sub supplier should be considered. Considering the changing
purchasing scope, individualization specifications also need to be developed at this stage.

This collaboration can be enabled by holistic, integrated, real-time IT infrastructure to allow cooperative work based on IoT capabilities. As Industry 4.0 technologies free up administrative resources, these resources should be invested into the early-phase to reduce cycle-times (P1-MA).

### 7.1.1.2 Select Suppliers

The management and purchasers agree, that the identification of suitable suppliers grows to a totally new challenge. Not only do current suppliers need to be assessed based on their technological fit but also new supplier in very early business stages need to be identified. Therefore, supplier identification becomes some form of external innovation scouting as well. Consequently, the process needs to offer higher flexibility for the individual purchaser, as predefined bidder lists would limit the exploration of suitable suppliers. The top management further states, that qualification information from current suppliers, will increasingly be gathered automatically through integration of functions and supplier data or from online publications. Further, BI technologies can deliver desired pre-assessments of the gathered information to simplify the pre-selection of suppliers. Based on the expectations of one purchaser, deep internal integration can further be used to simulate future scenarios to monitor supplier market developments based on past, current and future nominations.

The increasing individualization and customization further drives variants of components into an unmanageable level of complexity. Consequently, two developments are seen to occur simultaneously. Purchasers and sales representatives agree, that on one side, complexity of quotation request needs to be reduced and on the other side analytical system support needs to be increased. This means, that quotations should not be based on actual product variants but rather on parameters and axioms that can represent any variations of products. Additionally, an integrated and standardized interface needs to be offered concerning the system integrations with suppliers (S1-S2A). Industry 4.0 technologies hereby can deliver the required infrastructure for collaboration through IoT (Qin, et al., 2016).
The actual analysis of bids in Purchasing 4.0 can be based on a structured parameter cost breakdown from the quotation information. Following Kang et al. (2016), the system hereby would be able to combine cost information from different suppliers with own cost definitions from cost engineering to cross-analyze, compare best practices and suggest corresponding negotiation strategies to the purchaser. One supplier representative further states, that beside traditional cost information, further impacts from quality, logistics etc. need to be considered and quantified to enable holistic decision-making.

Based on both supplier representatives, the supplier selection will not encompass the entire chain, as sub suppliers are not assessed capable of actual end-to-end engineering. For the selection of direct suppliers, IoT can provide the necessary transparency and BI solutions allow to pre-assess the information to reduce the enormous pool of possibilities towards suitable scenarios. This could be done through simulations of scenarios as well as dashboard overviews based on supplier information. Considering BI potentials, entire supplier clusters or markets could be analyzed with consideration of current and future developments to support strategy development.

### 7.1.1.3 Negotiation and Contracting

According to the management and purchasers, to create the required level of competition, a large sub-set of potential suppliers is considered for negotiations, consequently the sequencing overlaps with the supplier selection sub-process.

Negotiations in Purchasing 4.0 are seen to be highly fact-driven (M1-MA). The usage of historical data from all areas provides the purchaser with the necessary tool to negotiate ‘true total costs’. Big Data and BI enable the smart analysis of previous bidding processes or negotiations and further can encompass other cost-relevant aspects like quality and supply issues. These analyses can be used to support the development and execution of suitable negotiation strategies with a holistic goal in mind. While both purchasers state, that the first negotiation rounds will increasingly be carried out through electronical auctions, the final negotiations will still be carried out by humans.

Based on the parameter and capacity agreements, contracts will be more loosely based on actual product demand. Correspondingly a sales representative expects, that
agreements will be made on capacity requirements and cost for different parameters such as production steps.

The management also claims, that beside the regular supplier frame contracts new forms of contracting will be used to integrate innovation suppliers, such as start-ups, into the supply chain (M3-MA). Correspondingly, compliance aspects need some form of adjustment to allow collaboration with new supplier types.

### 7.1.1.4 Change Management

Diverging from the generic process, ‘change management’, the negotiation and processing of commercial implications of technical component changes, needs to be considered within the strategic purchasing process (M2-MA, P1-MA, P2-MA). This cannot be seen as caused by Industry 4.0 but represents a general practice in the automotive sector, which is considered an important part of the purchasing process.

Based on precisely defined parameters, managers and purchasers expect change management to be fully automatically carried out through the interlinkage of technical and commercial systems with the supplier. Industry 4.0 technologies enable this required integration. Consequently, no further negotiations need to be carried out. Even where these direct linkages are missing, change management is seen to strongly improve through BI analyses of costing patterns at the respective suppliers to identify pricing strategies (M1-MA).

### 7.1.2 Operative Purchasing Process

Reported by all interviewees, the operative purchasing process will be less affected by changes through Industry 4.0, as automation maturity at manufacturer A on this level is already quite high. Nevertheless, real-time data and further automations will reshape the sub-processes.

#### 7.1.2.1 Ordering

According to both purchasers, the generation of purchase orders in the Industry 4.0 environment can be fully automatical be derived from system data and autonomously be send to the supplier. The holistic network, as described for RQ1 enables this linkage.

Calls-offs, that are already automatically generated can further be precisely adjusted based on production planning interaction between suppliers and manufacturers. This
interactive planning will be enabled through CPS, that exchange information through IoT beyond company borders (Hermann, et al., 2016).

7.1.2.2 Order Follow-up

All interviewed managers identify Industry 4.0 implications for the order follow-up. Considering technological potentials, delivery time tracking can be enhanced through CPS-based real-time information from the suppliers operations as well as precise location information. The same applies for quality inspections which can be enhanced through real-time data.

Based on the detailed information from suppliers and BI technologies, potential pit falls can be indicated or predicted early on, allowing to promote proactive management of suppliers rather than actual trouble shooting in case of incidents (M1-MA). Risk evaluations can increasingly be automatically carried out based on consideration of for instance meteorological data or financial performances (M3-MA). Hereby, the application of Big Data and BI enable both, the holistic inclusion of internet data as well as predictive analysis based on smart algorithms (Kang, et al., 2016)

Occurring incidents can be followed up on based on real-time data from suppliers’ production. BI is further expected to offer actual problem solving suggestion based on system information of requirements and the existing supplier base (M2-MA).

Considering the already automated self-billing, the actual billing of real costs estimated by the CPS at suppliers’ operations can evolve through Purchasing 4.0.

7.1.2.3 Evaluation

To evaluate suppliers, purchaser and supplier agree, that Big Data allows the holistic consideration of all information on the corresponding partner.

In a Purchasing 4.0 shaped process, supplier ranking and rating can not only be automatically carried out based on the information from different functions, but performance can directly be shared with suppliers to allow suppliers performance improvements based on best practices.
7.2 Case B

7.2.1 Strategic Purchasing Process

Considering the interview information on the strategic purchasing process at manufacturer B, the major impact on the purchasing process through Industry 4.0 is expected in the strategic purchasing process.

In general, it was pointed out by five out of six interviewees that a reduced time until the start of production (SOP) is expected. This will be the case due to faster processes, better decision bases and fewer changes. But not only will the processes be faster, the order of the processes is expected to change towards a more overlapping structure with less clear boundaries. Consequently, sub-processes and tasks can be performed simultaneously.

Overall the strategic purchasing process will benefit from a broader set of information in terms of amount of data available but also in terms of different data sources and analysis of data (S1-SB, M1-MB).

7.2.1.1 Define specifications

As pointed out in the interviews, several different partners are involved in determining requirements and specifications (M1-MB, P1-MB, M2-MB, M3-MB). None of the interviewees mentioned a system or platform support that exists for this purpose. As a stronger involvement of the purchasing department as well as the supplier was desired (M1-MB, P1-MB, S2-SB), it can be expected that due to a system-based Big Data solution or a rather IoT-based platform, a joint development and specification interface will be in place.

Based on that, the development and specification process can be accelerated, purchasers can be easier involved in it and make sure that the created specification is not too narrow to allow a competitive supplier base, and suppliers can provide their input for cost savings and optimizations.

Considering the interviews and the technological possibilities created through Industry 4.0, the interface will be interactive and provides every party involved with real-time information. Furthermore, through BI different alternatives can be analyzed automatically. Consequently, less system input and administrative tasks are required.
Moreover, this allows the easy usage of functional or concept tenders that require best solutions from the suppliers based on the pre-defined requirements, which was mentioned as desirable for the future by one of the managers.

Overall it can be said that the define specification sub process be more transparent, include all partners in an interactive, fast and direct way, and reduce administrative tasks due to less system interruptions.

7.2.1.2 Select Suppliers

With the help of Industry 4.0 technology, several elements of the supplier selection sub-process can be optimized.

For the prequalification of suppliers, the process can be improved by better data availability (M3-MB, P1-MB). This includes the automatic collection of supplier information from the internet, collecting data from other purchasing units, and direct access to supplier data. Through IoT and BI it will be possible to generate pre-defined information about supplier from the internet, which need to be collected manually right now. This reduces the administrative effort, assures faster availability of ad hoc news, and enables a better risk evaluation in terms of natural disasters. Especially for new suppliers, the collection of specific data that is not provided by the supplier is considered quite time consuming.

Nevertheless, this is also relevant for existing suppliers as it allows a constant updating. In case of suppliers that need to publicize their financial results, this could even be used to automatically collect this information from the internet and directly analyze them according to the requirements.

Furthermore, an automatic collection of supplier information from other purchasing departments will be possible through Big Data. In combination with BI, it will be possible to derive required information from this huge amount of collected data and if desired automatically analyze them. This provides the purchasers with more holistic information and less analysis steps to allow a better and faster decision making.

Furthermore, this process is also required due to the importance of new suppliers as pointed out in RQ1. These new suppliers need to be identified, audited and qualified (M1-MB, M3-MB, P1-MB). Furthermore, especially with respect to start-ups, traditional processes will not be applicable anymore as certain predefined criteria do not
fit to the business model of innovative companies. As those suppliers are also unexperienced in the automotive industry, in a lot of cases a closer supplier development and support with respect to standards and regulations common in the automotive industry will be required.

In the case of manufacturer B, a creation of the bidders list in coordination with other purchasing units of the group is quite important, as mentioned by two managers. Therefore, an easier sharing of data and more holistic data availability through Big Data and BI will improve this step.

With respect to the RFQ, a complete automation seems to be possible. By connection to the determining of the order specification and the creation of the bidders list, the determined specification could automatically be turned into an RFQ and be send out to the suppliers on the bidders list.

Furthermore, through system integration at the supplier’s side, one sales representative sees the potential, that the offer could be directly created and transmitted to manufacturer B based on the engineers input in the supplier’s system and approval by the sales manager. Based on that, the RFQ duration period and administrative efforts could be reduced drastically.

Cost breakdowns, which according to all manufacturer representatives create an important analysis and negotiation basis for manufacturer B, are currently collected on the B2B platform but need to be analyzed and compared manually. This step will be automated in the future due to system support that analyses the collected data, performance cross comparisons between the suppliers, and present the respective result to the purchase. This means the purchaser only needs to draw conclusions from the results but does not need to process the data. Additionally, if desired the results could be direct and anonymously shared with the suppliers to provide them with a benchmark and identify improvement potential.

The change towards parameter based prices, as discussed in RQ1, will also have influence on the RFQ process. As pointed out by the interview participants, currently RFQs are sent out for one components. This will change due to parameter based pricing. RFQs will be send out for a complete set of parameters with a certain product category in mind but no clear connection to a certain component. This means, the complexity of
RFQs will increase dramatically while the number of RFQs will decline. Consequently, the RFQs need to include new information, requirements and structures.

In some cases, the RFQ might even be replaced by an RFP as the comparison of different proposals will be easier through the help of Business Intelligence (M3-MB). A closer integration will enable the easy exchange of required information and communication which is one of today’s issues of RFPs.

Furthermore, the analysis of bids and supplier selection is expected by the purchaser as well as two managers to be supported by smart analysis tools which are automatically comparing prices and supplier rankings and creating the optimal combination based on pre-defined criteria. This will be support by better access to current performance measures which improve the supplier ranking and allow reaction to newly evolved issues or improvements.

For highly standardized and simple products, one interview participant pointed out that a complete automation of the supplier selection process would be possible. Based on predefined suppliers, the RFQ will automatically be send and the supplier selected based on the price or a predefined optimum of criteria. This could either be a preparatory step for the following negotiation or skip this step and directly award the order.

7.2.1.3 Negotiation and contracting

For the negotiation, the support of Industry 4.0 technologies will especially create advantages with respect to data analysis and preparation of the final negotiation step. For simple and highly standardized products it will even be possible to fully automate the negotiation process while for important products the interviews revealed that human interaction on the final stage will always be still required.

Right now, except for the use of e-auctions in some cases, no system support exists for the negotiation process (P1-MB, M2-MB, M3-MB). In this regard, smart analysis based on BI will help to create a negotiation advantage through analysis of past negotiations. Through the analysis of negotiation patterns, such as typical reduction steps of a certain supplier during the negotiation process, this could be considered in advance and provide the purchaser with a realistic price aim.
Furthermore, it can provide important insights for the final supplier selection as e.g. suppliers behaviour on change management topics, an important topic for manufacturer B and the automotive industry in general (M1-MB, P1-MB), could be analysed and used to consider these for the decision process.

Based on RQ1 and the interview with one manager, the subject of price determination will change from product based prices to rather capacity and parameter focused prices that form the base for different products. Consequently, the negotiation task will change. Responsibilities for certain capacities or components need to be defined and the interests of different functional departments need to be considered.

The contracting will primarily change through the general changes in purchasing with respect to parameter-based pricing, innovative suppliers, and the requirement of increased flexibility. This means, contracts need to be arranged in accordance with these new requirements.

For prices that are based on capacities and parameters and not a certain product anymore, the duration of such a contract need to be different. If the contract will not only influence one model but several, the duration cannot be based on the product life span of a certain model. Furthermore, the contracts do not only need to be designed more flexible with respect to the duration but also with respect to a more flexible product. This is driven by the production in the frequency in which the order is actually received and not a certain production program, as discussed by one manager.

Contract duration is also a critical aspect with respect to innovative suppliers. In a fast-changing technology setting, five to seven year lasting contracts are not applicable, as also pointed out by the management. Therefore, contracts in this context will either have shorter durations or a pre-agreement for technical changes and innovations.

The importance of start-ups will also lead to a higher flexibility that will be required for contracts. Standardized contracts will not be suitable anymore and new elements, such as investment of the manufacturer to enable the production at the start-up, need to be considered.

Another improvement is based on the demand of some interview partners for direct transfer of RFQ information into contract details without transferring them. Making use of IoT and BI in the purchasing process will enable this automatic transfer.
7.2.1.4 Change Management

With respect to the change management process, several reshaping aspects could be revealed from the interviews. As pointed out by all interviewees except for one manager, the change management process is related to high additional costs due to price increases. To reduce this problem, it can be made use of BI to automatically generate the adequate changed price based on the cost breakdown provided during the initial negotiation step. This will also enable the comparison of different changes to compare cost changes without further involvement of the supplier.

Furthermore, as pointed out by the supplier side as well as the manufacturer, right now there exist no system support for the change management process. Respectively, this process is quite time and work intense, as several documents and information need to be send back and forth. New technologies and closer system integration will automate the transfer of information and reduce the human interaction in this context. Especially as no further price changes need to be advised, the process can be highly automated and therefore also speeded up. This will lead to reduced process time and less administrative work.

7.2.2 Operative Purchasing Process

Considering the information received during the interviews, all interviewees expected the operative purchasing process to be less reshaped by Industry 4.0. This is based on the fact that the operative purchasing process is already considered to be quite automated, integrated and in most cases has a sufficient system support. In general, the operative purchasing process is expected by all participants to be further automated, which will consequently lead to a highly automated or even autonomous operative purchasing process.

7.2.2.1 Ordering

Even though the interview participants pointed out, that the ordering process is already quite digitalized and automated, there still exists potential for further optimization through Industry 4.0 technologies.

It was mentioned by one purchaser as well as a sales representative, that call-offs are executed by dispatchers in the system and send to the supplier via Electronic Data Interchange (EDI). This means human interaction is still required.
Through the usage of CPSs in production this will change, as these CPSs in combination with BI will be able to consider demands based on the pre-defined production program and consequently send a call-off to the supplier. Therefore, no human interaction will be needed for the call-off any more. This is getting even more relevant as the change towards a more flexible, demand driven production and therefore a more flexible ordering/call-off of material, will increase the complexity of this process (M1-MB).

Through communication of CPSs of manufacturers and suppliers, with the help of BI and IoT, the manufacturers system in the production will also be able to consider available capacities or delivery problems at the supplier. Based on that, call-offs and respective production programs can be planned accordingly and unexpected quantity changes easier considered.

Furthermore, one manufacturer representative expects for the initial order the creation to be further automated by turning the RFQ and contract information that are available in the system directly into the initial order. Based on this price changes in the system automatically will be displayed in the initial order and do not require any human interaction. This means a drastically reduction of required workforce and will speed up the complete process through less system interruption and direct access to information.

### 7.2.2.2 Order Follow-up

Similar as for the ordering process, the order follow-up was considered as already quite digitalized and automated by all interviewees. Order statuses are displayed in the system and material receipts are automated. Only trouble shooting seems to still be a quite manual task. Irrespective of that, full potential of digitalization and automation are not used yet, with respect to Industry 4.0 technologies (M3-MB). CPS and IoT will enable real time access to the production and delivery status (Qin, et al., 2016).

Considering the improved availability of production and delivery data, as well as the possibility of collection specific data about weather and natural disasters forecast from the internet, early warning systems will be possible. This will enable an earlier and therefore in most cases also easier trouble shooting as well as a reduced risk through better control.
Furthermore, the availability and system supported analysis of this data will in case of upcoming issues help to evaluate different solution scenarios based on a holistic set of information. This leads to a better decision basis, faster handling of problems and reduction of workforce.

Another change will happen through the previously already mentioned change towards parameter based pricing. Consequently, invoices will not be based on agreed product prices but on the actual costs.

7.2.2.3 Evaluation

Little potential for improvement was mentioned for the evaluation process. The only potential for changes through Industry 4.0, that could be identified based on one manager and one sales representative was the real-time availability of performance data for purchasing as well as for the supplier to react to upcoming issues immediately. Through CPS, BI and IoT, this will be possible to turn into reality. This will lead to a more holistic evaluation based on high quality and accurate data.

7.3 Case C

7.3.1 Strategic Purchasing Process

The interviewees at manufacturer C all pointed out, that most reshaping of the purchasing process will occur in the strategic purchasing process. The majority of changes have influence on certain sub processes, but there is also some general reshaping of the strategic purchasing process that could be identified. First of all, the sequence of the sub processes will change and the strategic process will be characterized by more overlappings. This is the case due to closer collaboration with suppliers and a stronger integration. Furthermore, the support of Big Data, Business Intelligence and IoT enable a change in the sequence as an improve information base exists and complex circumstances can be handled easier.

Furthermore, the Industry 4.0 context converts the strategic process in general into a more holistic and integrated process, which is characterized by access to and exchange of data from different actors, internal as well as external.
7.3.1.1 Define specifications

Considering the received information from the interviews in combination with the new possibilities arising through Industry 4.0 technologies, a further automated as well as integrated define specifications process can be expected.

As pointed out by M1-MC and P1-MC the definition of the order specification is right now a quite isolated task of the R&D departments in which purchasing is informed but not really involved. There is a clear desire by the purchasers to be more involved in this process and receive better information. Additionally, there is also the desire of supplier involvement in this process. The interviews revealed, that no system support for data exchange or communication exists right now with respect to the specification process. One purchaser pointed out, that right now this process takes a lot of time as information need to be send back and forth via e-mail and the transfer of information takes a lot of time and creates administrative effort.

Through the usage of IoT a joint interface for internal actors as well as suppliers will be possible. Direct access to design information and a both way communication will enable optimized specification and reduce the amount of problems upcoming on a later stage of the process. This will also, as desired by P2-MC, speed up the process and reduce administrative tasks.

Another aspect that was considered as desirable by P1-MC, which will be enabled through Smart Factories and IoT, is the transparence of suppliers’ processes. Having a clear and transparent understanding of suppliers’ processes will help to optimize product design, by considering suppliers’ processes already on an early stage and could lead to significant lower cost and a faster process.

7.3.1.2 Select suppliers

With respect to the prequalification of suppliers, the conducted interviews revealed, that this task is right now handled quite manual, involving several different actors and the allocation into one of the four categories is only performed once a year or fewer. Considering the possibilities arising through IoT and Big Data/BI, this process can be automated. This means, that through the collected data about suppliers a real-time classification of suppliers based on certain criteria will be in place, easily combining all required data, and reducing the required human interaction. This will assure the current
validity of the classification. Furthermore, IoT and CPS will support the prequalification task with the access to a more holistic data availability collected from other departments, suppliers, or other external sources.

For the bidders list, M1-MC pointed out, that right now the suppliers to which the RFQ should be send need to be selected manually in the SAP system. BI will change this towards an automated selection of supplier for the bidders list, considering criteria defined in advance or the usage of algorithms.

Even though after the manual selection of considered suppliers the RFQ is already send out through the system and available for the supplier on an B2B platform in which the offer is also entered, further changes will occur through Industry 4.0 in this context. As pointed out by the purchasers as well as one sales representative, so far there is no system linkage between manufacturer C and their suppliers for the RFQ and all data needs to be manually transferred by the supplier from their system into the B2B platform. In this context, IoT will help to better integrate the systems and enable the direct data transfer from the supplier to the manufacturer system. Furthermore, right now the B2B platform rather provides a one-way communication, as mentioned by one purchaser. In this regard IoT will lead to a joint interface as the removal of system interruptions and a possible interaction from both sides will be enabled.

Another factor that was considered by one purchaser is the availability of capacity information from the supplier. Currently not knowing about the available capacities at suppliers consumes a lot of time in the RFQ process as responses of the suppliers take quite some time and in some cases lead to the need of considering other suppliers. Through access to production data by CPS and the transparent availability of those by IoT, the purchasers will in future be able to directly consider the available capacities at suppliers and base their decision on that accordingly. Consequently, less e-mails for clarification are required and the processes is speeded up through the abolition of waiting time.

This sub-process will further be reshaped by the already in RQ1 discussed change towards parameter based pricing. The current procedure described by the interview partners in which the RFQs are send out for each product will not be applicable anymore. RFQs will need to cover all relevant parameters for a certain category of products that will be purchased from a certain type of supplier. Consequently, the RFQ
will be very complex and considering a lot of parameters. Nevertheless, the amount of RFQs will be much lower as RFQs are not required for every single product anymore, which will overall make the process faster and more efficient.

One of the core changes for the supplier selection process due to Industry 4.0 that was revealed through the interviews is an improved data analysis. As pointed out by all interviewees at manufacturer C, currently all analyses are done manually with the support of Excel sheets. Through Big Data, not only more data will be collected but in combination with Business Intelligence an automated and customized analysis will occur. This will affect the supplier selection process in the way, that offers and cost breakdowns can be analyzed and compared automatically. Consequently, the transfer of data from the SAP system to Excel as well as the manual analysis will be obsolete which means a much faster analysis of bids with reduced human interaction.

One manager and one purchaser pointed out, that price is not the only relevant decision criteria for manufacturers but other factors such as lead times, quality, or available capacity need to be considered as well. The combination of Big Data and BI will be able to collect all this data and provide an analysis considering all relevant factors based on a pre-defined scheme. This allows a more holistic and systematic evaluation of offers.

The increasing transparency and data exchange resulting from all these changes also enables a better feedback to suppliers especially with respect to their offered prices and improvement potential on price structure. This can lead to improved supplier performance in the future and respectively reduced costs for manufacturer C.

Furthermore, due to the expected change towards parameter-based pricing, the analysis base will change and the comparison of different suppliers will become more complex and difficult. Considering all different parameters and find the optimum supplier by also considering for example expected quantities for each product involved and the influence of respective parameters, increases the complexity of the analysis and therefore is only possible through the usage of Big Data and Business Intelligence.

7.3.1.3 Negotiation and contracting

For the negotiation, the interviews revealed two aspects, the change towards negotiation of parameters and capacities as well as a completely automated negotiation process for
simple products. As all interviewees at manufacturer C addressed the desire for parameter-based costing and pointed out that this will be enabled through Industry 4.0 technologies, this will also impact the negotiation process. Instead of negotiating prices for individual components, negotiations will have a broader parameter focus. On the one side, this will reduce the overall negotiations as once the parameters are negotiated and no further price negotiations are required. On the other side, those negotiations will be more complex and require a holistic focus.

As pointed out by P1-MC and P2-MC, it can be expected that with the help of IoT and BI the negotiation process for simple and standardized products can be automated. As of now, manufacturer C is not performing any further negotiation for these products and just selects the supplier with the best fit based on the received quotation (P1-MC). The reason for that is, according to P1-MC, the mismatch between effort and possible cost savings. Through technical support, negotiation on this product will mean no additional effort, as no human interaction is required, but will provide additional cost savings.

The change towards parameter-based price agreements will also effect the contracting task. Contracts need to adjust to new requirements and agreements related to this new approach. This means, contracts will not be related to one components but to a number of agreed parameters with one supplier for different components. Consequently, elements like duration, quantities or availability of capacities need to be defined in a different way.

7.3.1.4 Change Management

With respect to change management, new technologies will make this process easier and faster. As of now, changes require a lot of time for approval due to sending back and forth information and slow information transfer. This will be changed through faster interaction based on system integration and joint interfaces. Besides the exchange of information and approvals, another issue pointed out by one purchaser was the problem of reduced negotiation power in case of change management. This will change through the switch towards parameter based pricing which is enabled through Industry 4.0 technologies. This means the new price for the changed specification can directly be determined and does not need any further negotiation. Consequently, no unreasonable price increases will occur in this regard anymore.
7.3.2 Operative Purchasing Process

The operative purchasing process was described by all interviewees as already very automated and integrated. Therefore, only little change through Industry 4.0 is expected at manufacturer C in this context.

7.3.2.1 Ordering

The only change that will happen for the ordering process is the automation of the ordering process before SOP. While the ordering process is already automated once the serial production is started, on the initial stage the process is still handled quite manually, as pointed out by P1-MC. This is mainly based on the higher complexity, changing suppliers, and lower quantities/frequencies. Nevertheless, through IoT and BI this will be handled and also the more complicated pre-serial production ordering will be possible to be performed automatically.

7.3.2.2 Order Follow-up

Order follow-up will only be reshaped through the previously already pointed out change in pricing towards parameter based pricing. This will lead to invoicing based on true costs as well as invoices related to several different products.

7.3.2.3 Evaluation

No influence could be identified by the interviews for the evaluation process of manufacturer C.

7.4 Cross-Case Analysis

7.4.1 Strategic Purchasing Process

Throughout all cases it becomes obvious, that the strategic purchasing process has the higher relevance and potential, when considering how Purchasing 4.0 will reshape the purchasing process.

Based on the influencing factors (RQ1) and responses of case participant the general impact on the strategic process includes overlapping sequencing of sub processes, structural adjustments and a holistic and integrated IT-system. Further, closer internal and external integration is a key change.
7.4.1.1 Define Specification

Co-creation of purchase specifications:

Based on the need for closer joint development of specifications and the high necessity for shorter process cycles, specifications tasks need to be fused. Beside all required internal functions, suppliers will increasingly be involved in this early phase, even promoting own ideas through functional or concept tenders (case B), while disclosing own production capabilities for production (case C). This collaboration can be carried out within one integrated IoT based platform, to overcome current barriers. Regarding the increasing tendency to individualizations mostly found in case A, the specifications will further include information on expected customizability.

Consequently, this sub process will not only be speed up and digitalized, but the requirements definition is also extended to the expanded purchasing scope through product individualizations.

The reshaped sub process is mostly build on confirming case findings, allowing a high level of generalizability. Experts further confirm the changes towards individualization requirements and concept suggestions through the supplier (E3, E2). The early consideration of suppliers’ production capabilities must be seen as case specific finding at case C. This can be explained through the different volume settings in the car versus construction vehicle segment, that come with different power positions of the supply chain actors.

7.4.1.2 Select suppliers

Explorative and automated prequalification of supplier:

Case A and B show, that shaped by the need for more innovative suppliers, the identification of suppliers becomes increasingly relevant for the purchaser. This reduces the usability of currently mostly pre-defined bidder lists. The usage of Big Data and IoT technologies hereby allows automations of administrative compliance tasks, such as the analysis of published financial statements. While this was found most crucial in case A and B, also industry sectors with a less complex supplier base can benefit from these automations. System support is also seen to be key for the assessment of supplier information. Case A and B describe a qualification suggestion based on system information as desirable, while case C even presents the potential application of
automated supplier prequalification for non-critical components. Concerning organizational structures, case A further indicates a need for scenario simulations of supplier markets that can be presented to higher management.

Consequently, this sub-process step is shaped to become more explorative in terms of supplier identification. Most administrative tasks are automated and supported while interfaces are directly integrated through Industry 4.0 technologies, freeing up resources for strategic tasks.

In general, the explorative requirements and automation of administrative tasks can be confirmed by experts (E1). The level of BI usage hereby needs to be seen as based on the organizational requirements rather than the industry sector (E5).

Request for parameter quotation:

A clear tendency towards a different negotiation foundation already influences the RFQ. Based on high component complexity and new technological capabilities through CPS and IoT, all cases indicate the need for a change from product negotiations to parameter negotiations. This results in the request for parameter quotations at the supplier. This means, that requests will not center around product costs but the costs of different parameters or axioms, such as a production step, within a certain total capacity setting. Concerning this development, two case participants (P2-MC, S1-S1A) clearly state the difficulty of parameter based calculations, as additional costs need to be considered as well.

Beyond this drastic change, a direct interlinkage of manufacturer and supplier systems is expected to reduce the need for analysis in classical office software. This can be achieved through the usage of an advanced B2B platform in connection with BI tools. A further adjustment, only found in case C is transparency of available capacities at the different suppliers, to reduce request handling to actually capable suppliers.

As a result, this process step is seen to change drastically in its foundation through costing and further seen to be directly integrated between suppliers and manufacturers.

The shift towards parameter quotations was found in all cases and consequently can be generalized. The before-mentioned capacity transparency on the other side can be seen to be more specific for low volume requests like found in the industry sector of case C.
Request for innovation proposal:

Case A and B present the requirement of a bypass to the classical quotation handling to allow the potential consideration of early business ideas for instance from start-ups. While this might sound like a simple adjustment, it comes with interventions into compliance and related internal regulations. This would mean, that purchaser requests simplified costing overviews for innovation concepts, that are still being developed.

Considering this process bypass for innovation suppliers, generalizations can be made for just the premium car sector as the corresponding costs and risks can only be compensated in the high-price car segment.

Automated true total cost analysis:

A direct interface from RFQ to cost analysis is described in all cases (B2B collaboration platform). Following the adjusted costing approach, analyses need to be carried out on parameter and scenario levels. This analysis can be performed through BI technologies, making the usage of self-created excel analysis more obsolete.

Beyond the analysis of bids, all cases see the need to expand the supplier analysis through further considering ‘hidden costs’. Two simple examples of this are costs from quality or delivery issues. Derived from case A a quantification of these extra costs based on historical data and corresponding Big Data applications is aimed for. Case B and C see the deeper consideration of these indirect costs as highly relevant for decision making but do not present the requirement to actually quantify them.

Case A further presents the possibility to include highly strategic analyses into the system reports. This could for example describe market changes in a supplier industry through simulation of decision implications, further promoting the commercial goal to create highly competitive supplier markets.

Case B and C indicate high potential for providing direct feedback to the suppliers in form of benchmark or best-practice communication to promote direct improvements and hereby speed up the negotiation process.

Consequently, this process step becomes more integrated and automated, considers costs and analysis from a highly holistic perspective and even communicates results back to the suppliers.
The before-mentioned changes can be generalized to a large extent. While integration and automated parameter analysis can be considered relevant for the entire industry, the quantification of true total costs only makes sense when the required historical data is at hand. This is rather the case for traditional components. The transfer of feedback, only found in case B and C, on the other side can be generalized for the entire industry (E3). Highly complex supplier market analyses, found in case A, are most relevant in large, multi-branded organizations like found in case A and B.

*IT-supported selection of direct suppliers:*

Diverging from general tendencies to a closer end-to-end focus, the selection of suppliers in the automotive industry is mostly restricted to direct suppliers, based on industry limitations throughout the supply chain.

In Case A and B, a strong system support is expected to result in nominations suggestions based on holistic data considerations. Case C even considers an automated supplier selection decision for non-critical components.

This results in strongly system-supported supplier selection generalizable for the automotive industry. An actual automation of selection at case C can be explained by the purchasing context of the interviewed purchasers. Automations in this regard can only be claimed to make sense for highly standardized and non-critical components.

### 7.4.1.3 Negotiation and Contracting

Considering the shortening process times, an increasing overlapping of negotiations and supplier selection must be expected based on all case findings.

*Fact-based electronic negotiations:*

In accordance with the adjusted costing approach, negotiations in all cases are seen to become parameter-centered. In case A and B, negotiations are further expected to become strongly fact-based in terms of consideration of analytical information on suppliers’ historical negotiation behaviors.

While electronic negotiations in all cases are seen to become more relevant with increasing advancements in BI and artificial intelligence technologies, case A and B findings present a higher importance of human interaction especially for final negotiations. As a consequence, this process step will be not just electronically
supported but negotiations patterns and strategies of suppliers will increasingly be considerable for purchasers.

In terms of generalizability of these findings, it needs to be stated, that the extent of analytical considerations depends on historical data, therefore is effected by purchasing context and size of the manufacturer. The degree of applicability of electronic negotiations further strongly depends on purchasing context, such as component characteristics and markets.

*Capacity contracting:*

Based on the changed costing focus, traditional contracts and nominations will be centered around the parameter cost agreements. This of course needs to be done within a certain capacity frame which is part of the contract. Based on the changing purchasing scope and shorter product lifecycles, contractual agreements further will have shorter time frames. Case B in this regard further presents the need for flexibility contracts, allowing the deduction of demand driven production throughout the supply chain. An automation and system support hereby is seen through integration of final RFQ and bidding data directly into the contractual agreements (case B).

Consequently, reshaped contracting becomes capacity focused and system integrated, which can be generalized to the automotive industry.

*Investment contracting:*

A second change in contracting can be described as investment contracts with start-ups, in which a rather loosely calculation for a not yet finalized component are agreed on and development financially supported. This is seen critical in case A and B, to allow a short time-to-market for innovations but cannot be claimed for case C.

The tendency towards investment contracts needs to be restricted to automotive sectors that depend stronger on external consumer-oriented innovations, like the premium car segments.
7.4.1.4 Change Management

The management and negotiation of technical changes of components in all cases is described to be highly critical and resource consuming. The general relevance for a commercial management of technical changes needs to be seen as industry driven and cannot be declared to be linked to Industry 4.0 influences.

*IT-enhanced management of technical changes:*

An IoT based system support, linking technical and commercial aspects from the manufacturer and supplier is expected to simplify collaborative change management in Purchasing 4.0 in all considered cases.

Consequently, technical and commercial changes could be conducted in a holistic and integrated system in which all required actors collaborate. These findings can be generalized for both considered automotive sectors.

*Autonomous negotiations for technical changes:*

Prior changes towards parameter agreements already present a solution to reduce time-intense re-negotiations for technical changes, as cost parameter are set. The automation of change negotiations hereby is seen to become highly autonomous in all cases. This can be seen as enabled by IoT technologies.

According to these changes, the reshaped sub-process will strongly be automated through set parameters and interlinked IT-systems. These findings can be generalized for both considered automotive sectors. Highly cost-driven automotive sectors (low-cost products) are expected to be less affected, as technical changes are less considered.

7.4.2 Operative Purchasing Process

Concerning the operative purchasing process the general picture in all cases illustrates a lower relevance and potential compared to the strategic one. This can be explained through the already high maturity that can be found in the automotive industry based on EDI technology (Schmitz & Platts, 2004). Nevertheless, the process is assessed to be reshaped by real-time information through IoT as well as further automations.

Based on a higher satisfaction of interviewees with the operative processes at case C and the semi-structured interview approach, an imbalance in case contributions needs to be acknowledged. This imbalance cannot be explained by the industry sector but rather
needs to be affiliated with a random case development. Some influence can further be credited to the smaller size and correspondingly lower complexity as well as the different countries of origin, which represent different business practices.

7.4.2.1 Ordering

Derived initial order:

The initial purchase order, which activates the contract for following call-offs, can in Purchasing 4.0 be based on deeper integration to be automatically derivable. Consequently, administrative tasks are reduced through improved integrations. While this change is presented in case A and B, there is little doubt about a general feasibility and usability for other automotive sectors and organizational types (E3).

Interactive call-offs:

Referring to the actual call-off, CPS and IoT enable an interactive, autonomous production planning, not just in own operations but throughout the chain. This means that basically production machines communicate with each other beyond company borders, considering different capacities and routings for a highly demand driven production set up. Respectively, Kagermann’s (2015) understanding of linked smart factories would be considered. In this setting, call-offs will be automatically created and iteratively distributed downwards the supply chain. This change is mostly found in case A and B, where dispatchers are strongly involved in planning adjustments. In case C, the process is already described to be highly autonomous, which can be explained by the lower complexity and volumes in this industry sector.

Case C further presents a change for the pre-serial purchasing, mostly for prototypes and testing. While this process is considered highly manual, BI and IoT technologies are seen to allow automations in this regard. As a result, the internal integration with development as well as system support can provide a simplified purchasing of early prototypes. This finding must be seen as solely derived from case C with no further consideration of either other participants or experts. Nevertheless, seems this change theoretically applicable throughout different sectors of the industry.
7.4.2.2 Order Follow-up

Real-time tracking:

CPS in connection with IoT opens up a new dimension of delivery tracking. According to case A and B are these two technologies relevant enabler for real-time tracking. This results in up-to-date information of current production progress of orders even including location information during the delivery process. While these effects are found in case A and B experts confirm this change as industry wide change (E2).

Proactive trouble shooting:

Similar are the changes to trouble shooting. Based on stronger integration of suppliers and BI technologies, early warnings and predictions can be used to reshape trouble shooting from a reactive character towards a proactive one. Case A and B even present the possibility to use Big Data and BI to consider risks such as meteorological occurrences into trouble shooting. Beyond a pure identification of potential risks, the system is expected to combine existing data to suggest problem solving possibilities, such as a capacity shift to a different supplier. Case A and B further see the relevance of real-time trouble shooting based on CPS and IoT applications. In a result, real-time data creates a pro-active trouble shooting.

While these findings are only derived from case A and B, the lack of considerations in case C can only be described through a weaker focus on operative applications through the participants.

True cost invoicing:

Based on the new costing structures described above and CPS in combination with smart products, that precisely identify production steps, a real cost invoicing for each component can be created. This becomes interesting when considering highly individualized products, such as interior components and therefore cannot be generalized to case B and C. Nevertheless, is the entire premium sector suited for this adjustment (E2)
7.4.2.3 Evaluation

The evaluation sub process is little discussed in all cases, nevertheless are some adjustments obtainable.

Holistic supplier evaluation:

Industry 4.0 technologies around IoT and Big Data allow a holistic real-time evaluation of supplier. KPIs from different functional areas can be combined and evaluations even executed for sub supplier. This creates an all-encompassing evaluation that allows to identify performance issues at their roots. While the relevance for this approach is derived from case A and B it can be expected that, also less complex supply chains like in case C can benefit from this (E3).

Rating feedback:

Improved integration with suppliers can also be used to provide direct feedback to the supplier. An application, purchasing is mostly influenced by, is the feedback for offers and bids. Here internal information on own cost targets and calculations as well as supplier information on best practices can selectively be shared to allow suppliers to improve their offers before actual negotiations are carried out.

These findings again are derived from case A and B. Case C as well as any other automotive sector can also be expected to see this change.

7.4.3 Generalizing a ‘Smart Purchasing’ Model

Combining these changes into a model for a ‘Smart Purchasing Process’, an evolution to the current practices can be obtained. Figure 11 illustrates this model in a comprehensive matter. The figure hereby also shows the iterative steps of the research approach. The graph hereby derives how the business implications of Industry 4.0 influence the purchasing, creating a Purchasing 4.0 environment with changed scope, collaboration, structure and infrastructure. The reshaped process is illustrated with new and adjusted sub-process (bullet points) further indicating the crucial generalizability limitations.
Figure 11: ‘Smart Purchasing’ Model

1 only partly generalizable
8 Discussion & Critical Reflection

Building up on the findings generated in the previous chapters, a critical review of these findings is performed. Challenges with respect to Purchasing 4.0, the suitability of the term ‘4.0’ as well as the relevance for other areas are discussed in this regard. Furthermore, the generated findings are compared to previous theory, expected outcome, and non-academic publications. Lastly, societal and ethical considerations connected to Purchasing 4.0 are discussed.

8.1 Critical Reflection of Findings

Considering the presented findings, some critical reflections need to be mentioned. While many critical remarks can be affiliated with the defined research limitations, further reflections can be obtained from empirical data and secondary sources.

Based on the research approach, the generalization potential of the conducted study is rather high but still limited. Even though several consensuses could be identified, the automotive industry consists of several different sectors, with different characteristics. An example for these differences provides the high relevance of change management in the premium car sector, which is less present in the low-price car segments.

Furthermore, the findings cannot be generalized to all European countries or even a global context. As Industry 4.0 is of German origin and slowly spreading to neighboring countries, the understanding is different in most countries. Already for Sweden, a lower concept awareness was explorable. Beyond this, it also needs to be mentioned, that especially in developing countries the infrastructure and the current state of technological advancement are not sufficient to consider Purchasing 4.0 yet. This is concurrent with the statement, that at supplier C the level of system integration in the operative purchasing process is around 95% in Sweden and Germany but close to zero in China. Consequently, the geographical background of the manufacturer as well as their suppliers need to be considered.

Considering the multiple perspective approach of this research, it needs to be mentioned, that little discussions were possible on the detailed perspective level, as no clear patterns could be identified. Observed differences rather need to be affiliated with different case settings, purchasing contexts or personal opinions and are respectively discussed in the analyses chapters.
Additionally, it needs to be considered that Purchasing 4.0 is also connected to some challenges. To which degree these challenges can be managed will influence to what extent the purchasing process will respectively be reshaped.

To implement Purchasing 4.0 and a reshaped purchasing process, the commitment of the top management is essential. A clear 4.0 vision needs to be communicated from the top, to steer the development in one direction. As the interviews showed, this is not the case yet. Therefore, a change in this regard is first required to enable a successful Purchasing 4.0 implementation.

Purchasing 4.0 further requires skilled employees, that are able to work in the new context. Employees need to have a digital mind set and need to be analytically skilled. To assure this, employee trainings will be required. Nevertheless, there is the risk for companies of not finding enough suitable employees for the changed context. This concern was also pointed out during the interviews, especially by the management level.

Additionally, the willingness of the supplier for closer system integration and collaboration needs to be provided. Even though the interviews revealed, that a general willingness of suppliers in this regard exists, it was also pointed out that a win-win situation needs to be assured.

Financial investments are another crucial aspect. The costs for new technologies and changed infrastructure need to be justified by the advantages created through it. The required investment also carries the problem, that especially smaller suppliers might in some cases not be able to invest the required amount.

Another issue, that could cause problems for the conversion towards Purchasing 4.0 are the historically grown structures, especially at large multinational car manufacturers. As shown in the previous chapter, the reshaped purchasing process requires adjustments in the organizational structure. More flexible and overlapping structures need to replace the current organizational, function-based structures to enable changes like project islands and parameter costing.

Furthermore, the purchasing process in the automotive industry can be described as quite complex with little standardizations. Respectively, it will be difficult to create the holistic and comprehensive view to satisfying all needs. The interviews showed that processes and practices differ a lot between different departments as well as companies.
Consequently, standardization is required. In this regard, several interview partners called for the involvement of independent associations to set certain standards.

One aspect that is already relevant in today’s business environment but will become even more crucial in a Purchasing 4.0 setting, is data security. It needs to be assured, that nobody from the outside can access the data as well as that data is not send by accident to the wrong party (e.g. a competitor of the customer or supplier). Nevertheless, little concern was expressed by most participants in this regard.

It also needs to be considered, that the described Purchasing 4.0 setting results in increasing complexity, higher need for flexibility and drastic changes in IT-infrastructures. Consequently, ways to deal with this need to be found.

Besides these remarks, the term ‘4.0’ in this context needs to be critically reviewed. It could be argued, whether all aspects are fully Industry 4.0 based. This is mainly resulting from the fact that Purchasing 4.0 is building up on existing infrastructures (e.g. B2B platforms, e-auctions, EDI) but brings them to a new level with a focus on automation, smart systems, and integration. Nevertheless, looking at the results, Industry 4.0 literature, and the conducted interviews, it needs to be concluded that the ‘4.0’ label overall is suitable. Considering the strong relevance and driving force of Industry 4.0 in this context, just labelling this change as ‘future purchasing’ or ‘technology-based purchasing’ would not represent the focus of this research.

Even though several influences of Purchasing 4.0 could be identified in this thesis, it needs to be mentioned that other areas such as Logistics 4.0, Supply Chain 4.0, or Industry 4.0 itself, provide more potential and drastic changes.

8.2 Comparing Findings to Theory & Expected Outcome

Comparing the findings to the theory and expected outcomes, some results are surprising, while many findings could be presumed beforehand.

Several general statements within the context of Industry 4.0, which were pointed out in the introduction, could also be identified to apply for Purchasing 4.0. The automation of processes, increased amount of collected and accessible data, easier and faster use of data, employees focus on important tasks, as well as increasing transparency were all confirmed to not only apply in the general Industry 4.0 context, but also for Purchasing 4.0.
Considering further non-academic publications on this topic, some unexpected results can be found. First of all, the imbalance of technological influences was unexpected, especially with respect to CPS as the trade journal ‘Beschaffung aktuell’ expected a direct and strong relevance of CPS in purchasing (Mohr, 2016). Additionally, the high relevance of parameter-based costing was a surprising finding from the interviews as no publications trigger costing influences.

Moreover, even though a stronger strategic focus was expected (Pellengahr, et al., 2016; Geissbauer, et al., 2016), the level of impact on the strategic purchasing process and the little relevance for the operative purchasing focus was unexpected. This might be explainable by the already high degree of automation and digitalization in the operative purchasing process in the automotive industry. The topics end-to-end engineering and end-to-end integration, which were commonly mentioned in the Industry 4.0 context (Stock & Seliger, 2016) and therefore also expected to be relevant for Purchasing 4.0, were not seen as fully applicable.

Furthermore, the currently not existing relevance of Industry 4.0 for the production at manufacturer C was a surprising result as a general relevance of Industry 4.0 for the production of automotive manufacturers was expected.

8.3 Societal & Ethical Considerations

Besides the commercial impact of Purchasing 4.0, it is also important to consider the societal and ethical impact arising from it. In this regard two main topics need to be considered, the workforce and sustainability.

The core challenges for companies and the society in this context will be the replacement of employees by machines or technologies. Some of the main advantages discussed are less administrative tasks, increased automation and less human interaction. Consequently, tasks that are currently performed by people will increasingly be performed by technologies. This will especially affect lower qualified employees. In most cases, the required skills and reductions in the overall count will not allow to just transfer these employees to new tasks. Therefore, companies already must take this into consideration now and create a plan to steer the workforce in the right direction and invest in training to develop skilled employees for the future. Only if companies react early enough to this change there is still enough time to prepare employees for new
tasks and consider the expected changes in employee planning to minimize the negative societal impact of this change.

As pointed out by Qin et al. (2016) the change towards Industry 4.0 also provides a societal advantage for European countries. The aging population and a lack of skilled workforce are seen as one of the core challenges the society as well as the business world are facing in most industrialized countries. The change towards Industry 4.0 and consequently Purchasing 4.0 can help to reduce the negative impact and respectively help to secure the economic wealth of these societies.

With respect to sustainability, several positive effects can be identified. First of all, some interviewees pointed out that Industry 4.0 will lead to a nearshoring or re-shoring trend as low-cost workforce will be less relevant in contrast to a more important close proximity to customers. Consequently, this will lead to less emissions through transport, less exploration of workers, and more consideration of environmental standards in production. Additionally, Purchasing 4.0 comes with an increased transparency. This means suppliers can be better controlled also with respect to sustainable considerations of environmental and social factors.
9 Conclusion

The following chapter firstly provides an overview of the findings generated with respect to research question 1 and 2. Secondly, theoretical and practical contributions and implications of this thesis are outlined. Furthermore, ethical and societal implications are pointed out. This is followed by an evaluation of the limitations of the conducted research as well as the reliability and validity. Finally, suggestions for further research arising from the conducted study are presented.

9.1 Answering the Research Questions

The conducted research provides extensive findings to answer the formulated research questions of this thesis.

Referring to the first research question on the influence of Industry 4.0 on purchasing of automotive manufacturers, the following findings were obtained. All Industry 4.0 business implications from advances in technologies and manufacturing to changes in integration and business context were explored to influence purchasing. Many indirect causal interlinkages hereby were found between these categories. According to the findings, the direct influence from technologies is reducible to Big Data & BI as well as the Internet of Things. Further, changes in own manufacturing and changes in vertical and horizontal integration are proven to have a direct influence on purchasing. The most influences can be affiliated with the changing business context, whereas changing products, suppliers, business models and a new purchaser role influence purchasing.

An analysis of the impact of these influences allows a translation into a Purchasing 4.0 setting, comprising of a changed purchasing scope, structure, infrastructure and collaboration. According to the findings, the Purchasing 4.0 scope encompasses innovative, digitalized, individualized and fast changing components, that need to be purchased from new or developed supplier base. Further, the role of the purchaser becomes strongly strategic and analytical. In addition to this is the purchasing scope extended through new costing practices. The underlying organizational structures in Purchasing 4.0 tend towards process-oriented project islands, enabling co-creation. The corresponding Purchasing 4.0 infrastructure can be described as shaped by holistic networks, collaborations platforms and assisting systems. The purchasing collaboration will also be affected as cross-functional integration and the approximation to end-to-end...
engineering increases. Collaboration changes further comprise interactive planning and co-optimization tendencies.

Based on these findings, the second research question on the reshaped purchasing process of automotive manufacturers through Purchasing 4.0 can be answered. The reshaped strategic purchasing process hereby encompasses a co-creation of purchasing specifications, an explorative and automated prequalification of supplier and a request for parameter quotations. An additional request for innovation proposal is further added. Analyses are carried out automatically including former hidden costs. The selection of direct suppliers is further strongly IT-supported. Negotiations can be described as strongly data and fact-driven, carried out electronically. The contracting in accordance with a new parameter costing approach will be capacity-focused, while new forms of contracts allow early investments in innovative concepts. The management of technical changes even becomes autonomous based on the changing purchasing infrastructure.

The operative purchasing process is strongly reshaped through real-time information usage and integration-based automations. Consequently, initial purchase orders can automatically be derived from the system and call-offs are created interactively in integrated Smart Factories. Order-follow up is carried out in real-time further enabling a proactive trouble shooting. Based on interlinked operations, costs are invoiced in accordance with actual resource consumptions. The supplier evaluation can further be described to become highly holistic throughout the supply chain with direct feedback to suppliers.

Based on the three different cases, that include not only different automotive industry sectors but also represent different purchasing contexts, a rather high level of generalization can be obtained. Further, expert assessments confirm most findings. However, generalization restrictions need to be considered for some findings, that represent case or industry sector distinctions.

9.2 Research Contributions & Implications

The theoretical contribution of this thesis needs to be seen on different levels. Firstly, the thesis provides new theoretical elaborations already within the theoretical framework. Here, the creation of an automotive focused purchasing process needs to be mentioned, as no existing theoretical elaborations could be found during the research.
Further, the systematic classification of Industry 4.0 definitions and understandings can be seen as theoretical contribution as existing literature reviews are restricted to technological and conceptual discussions. Secondly, considering the findings, the research presents a theoretical foundation for influences of Industry 4.0 on purchasing, that can be adjusted to industries and contexts. The visionary reshaped Purchasing 4.0 process model can hereby be seen as groundwork for further research into actual system solutions. This thesis expands the theoretical foundation of cross-discipline research on Industry 4.0 to the purchasing field as first scientific research in this area.

The practical contribution or practical implications offer valuable knowledge to all considered entities and perspectives. Based on the Purchasing 4.0 setting and process model, automotive manufacturers can develop a holistic strategy that is required to revolutionize purchasing. Suppliers can further deduct corresponding scenarios to allow future compliance at the purchasing-sales interfaces. Even the included experts can draw conclusions by considering relevant implementation issues to create consulting concepts for.

Within the discussion, several ethical and societal aspects were explored, that create further implications. Most important in this context is the early consideration of Purchasing 4.0 effects on the workforce. Companies in this regard need to be advised to offer trainings, which also allow elderly and less educated employees to work within a highly digitalized setting. Regarding sustainability effects, Purchasing 4.0 offers promising solutions with respect to supply chain transparency and reduced need for offshoring. Consequently, Purchasing 4.0 can also contribute to an organization’s sustainability efforts.

9.3 Limitations & Reflections on Validity and Reliability

Beyond the defined delimitations of the research, further occurred limitations need to be considered. While the approach to address quite distinct industry sectors and component categories offers great potential to explore a wider range of influences, this also comes with the risk of biased findings. This risk hereby was reduced through the inclusion of independent experts. Another limitation needs to be mentioned in terms of considered manufacturer perspectives. While managers and purchasers were included, the developed cross-functional changes would have benefited from closer involvement of internal process partners like, development and design, to assure the common interests.
Further, the strong focus on the focal company in this research, reduced potential discussion on different perspectives in the supply chains.

Beyond the general reflection on the research findings (presented in chapter 8), it is important to further reflect on the research quality in total. Hereby it can be stated, that following generally accepted and highly systematic research methods was crucial to the success of the research. Concerning the research validity, especially for the wide ranging understanding on Industry 4.0, operationalisations were important to ensure that all interviews covered the same conceptual construct. Considering the high mass of semi-structured empirical data, Mayring’s Qualitative Content Analysis helped to reduce confusions and diverging classifications. In terms of reliability, a final follow-up with the interview participants lead to the adjustment of smaller misunderstandings that could be affiliated with a potential researcher biases. Overall, the research approach successfully created the required validity and reliability, that was aimed for.

9.4 Future Research

The presented research offers different opportunities for future research. Firstly, the research scope can be extended to different industry sectors and the inclusion of purchasing strategies as well as tools and systems. Also, the analysis of Industry 4.0 implications on purchasing in different purchasing contexts (e.g. indirect material) and countries seems promising. Secondly an in-depth analysis of presented solutions, like integrated and holistic IT-systems, would provide a theoretical and practical value. Further in-depth analyses could also include a validation through larger quantitative data collection and the exploration of feasibilities and implementation options. Thirdly, some presented findings, such as ‘data as business model’ and ‘parameter-based costing’ require deeper research to create sound conceptual models.
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Appendix

Appendix A: Empirical Findings

Case A

Influences Through Technologies

CPS: According to the management at the focal company, no direct use of the Cyber-Physical Systems or devices with the purchasing department can be imagined (M2-MA, M1-MA, M3-MA). The usage of CPS information from manufacturing is estimated as important step for deep integration (M3-MA). According to purchasers, highly relevant data includes: actual production parameter, material usage and scrap, production plans in the supply chain, location data as well as quality data (P1-MA, P2-MA). From the supplier side, real-time production planning data is mentioned to be relevant (S1-S1A). The possible usage ranges from cost assessments, volume/capacity planning, incident follow-ups, and quality management.

IOT: The Internet of Things and Services is considered highly important (M3-MA, M1-MA). All parties consider an internet-based network structure as critical. The stated use cases comprise of: interactive workflows between computers and smart phones/tablets (P2-MA), scenario simulations (P2-MA), real time data exchange with suppliers (S1-S1A, S1-S2A), collaborative forecasting and planning (S1-S1A) and fact driven cost breakdowns (S1-S1A).

Big Data & Business Intelligence: Big Data and Business Intelligence is stated to be highly relevant (P1-MA) and claimed to have the highest potential for purchasing (M1-MA, M3-MA). The scope of this technology is considered for: internal historical data (M2-MA, M1-MA), data from different functions and hierarchy levels (M1-MA, M2-MA, S1-S2A), supplier data as well as public information from the internet. The application reaches from: structuring and prioritizing of supplier related data (M3-MA), Pre-assessments of performance and bids (M2-MA, P2-MA), combing of function specific data (P2-MA), predictive analytics for suppliers and supply (M3-MA, S1-S1A).

Smart factory: Smart factory technologies are stated to have no direct application in purchasing (M2-MA, M1-MA, M3-MA, P1-MA). Influences are considered in terms of different supply strategies from make instead of buy (M3-MA) up to relocations and back shoring to smart factories closer to the customer (M2-MA, P1-MA).
Influences Through Production

From the purchaser point of view, little direct influences on daily purchasing practices are expected (P2-MA, P1-MA). It is stated that a logical gap between production and purchasing exists (M3-MA). Management nevertheless also sees the influence of a new purchasing portfolio, as production units need to be supplied with industry 4.0 technologies (M1-MA). Most participants within the focal company mention a strong influence on data access and quality (M1-MA, M3-MA, M2-MA, P2-MA). Access to production-related data is expected to improve, affecting the data quality for purchasing practices (M3-MA, M2-MA). From the supplier side, a similar picture can be drawn. The direct influence on purchasing practices is assessed low (S1-S1A), while new levels of supply chain integration beyond collaborative demand management are expected (S1-S2A). A focus on data access, even in real-time is further mentioned, which might influence planning interactions (S1-S1A). Further the increasing efficiency is stated to become a selling proposition for suppliers within the industry (S1-S2A, S1-S1A)

Influences Through Changing Business Context

Products are expected to change towards sensor equipped, software driven components (M2-MA, M1-MA, M3-MA). Also, products based on new production technologies like 3D applications are considered (P1-MA). Nevertheless, are some classical components expected to remain largely unaffected (P2-MA, S1-S2A). Further changes in volumes are expected. High individualization preferences will lead to very small batch sizes (M2-MA, P1-MA, S1-S2A). Considering these changes, the manufacturer is expected to have a different role in the supply chain (M2-MA).

Supplier changes comprise of inclusion of new and innovative suppliers. These suppliers are expected to be new to the automotive industry, smaller and sometimes rather in an early state of business (start-ups) (M3-MA, M2-MA). Also existing supplier are required to adjust to potentially shorter production cycles (M3-MA).

Business models within the supply chain will further influence purchasing at focal companies. New businesses are to be considered in terms of generated data through sensors at customer and supply chain level (M2-MA, P1-MA). Collaboration in general will increase (M2-MA, M3-MA), shared/open innovations become relevant and mutual transparency will increase leading towards open books (M3-MA). Costing is further expected to be rather parameter/axiom than product based and even expected to be accounted at actual level of cost.
generation (S1-S2A). Concerning contractual agreements, software will increasingly be licensed and cycle will be reduced (M2-MA, M3-MA, P1-MA, P2-MA). Further contract agreements might become shorter and more flexible (P2-MA, P1-MA).

Most participants agree, that the purchaser function will become increasingly strategic, focusing on analyzing and decision making with less operational systems tasks. The cross-functional project management will rely on interface integration and co-creation (P2-MA, M2-MA, P1-MA, S1-S2A). The operative purchasing tasks (order processing) are expected to be automated (P1-MA, S1-S2A). The respective organizational structures and process in which purchasers perform are expected to adjust towards more flexibility (M1-MA, P1-MA, P2-MA).

**Influences Through Changing Integration**

In terms of vertical integration, a decrease in functional isolation and a stronger process view are expected (M3-MA, S1-S2A). Organizational changes hereby lean towards cross-functional project island (S1-S2A) focusing on holistic but faster purchasing decisions (S1-S2A, M2-MA). Generated data is expected to be shared through hierarchical levels and along all functions within an integrated and holistic system (M3-MA, P2-MA, M1-MA, P2-MA, S1-S2A).

Horizontal integration along the entire chain is considered highly relevant (P1-MA, M2-MA, S1-S2A). In this sense participants call for end-to-end engineering approaches (P1-MA, P2-MA). The feasibility to integrate all tiers on the other side is questioned strongly (S1-S2A, S1-S1A). From a system perspective, B2B portals are expected to develop towards actual collaboration platforms allowing collaborative planning and system automations (S1-S1A, M1-MA, M3-MA). This collaboration can also be imagined as feedback integration into the negotiation and bidding process (P1-MA, P2-MA).

**Current Purchasing Process**

*Define specifications:* The determination of requirements are handled by different functions. The technical aspects are handled by developers, while purchasers influence commercial aspects like feasibility and market explorations (M2-MA, P1-MA, P2-MA). The purchase order specifications are provided through company-wide framework conditions added by volume, flexibility and supply agreements (P1-MA).
Supplier selection: Supplier selection is a main responsibility of purchasers (P1-MA, P2-MA). Supplier nominations are even carried out for sub suppliers (S1-S1A, S1-S2A). The prequalification of suppliers is based on a bidder list provided by higher management (M2-MA). The Request for quotation is shared through a B2B portal (P1-MA) and consist of a highly complex quotation analysis form (P1-MA). The analysis of bids is mostly carried out mainly in excel, while the system already offers simple reporting (P1-MA, P2-MA). The actual supplier selection is carried out after negotiations with several potential suppliers (M2-MA).

Negotiation and contracting: Negotiations are carried out in close collaboration with cost engineers (S1-S2A). In high priority negotiations, management is involved (M2-MA). In special occasion become contractual agreements part of the price negotiations (P2-MA). After several negotiation rounds, which can also be performed electronically, the supplier is selected by all process partners and approved by different organizational committees (M2-MA, P2-MA). The contract agreement is not based on a classical contract but rather a nomination letter.

Ordering: The initial purchase order activates a current contract, usually for a year, and is created by the purchaser (P1-MA, P2-MA). The actual call-off are managed through the operations in a highly automated process (M1-MA, M3-MA, M2-MA).

Order follow-up: The order-follow up is strongly automated and mostly handled by the operations (M2-MA). In case of escalations, purchasers or even management is involved in trouble shooting.

Evaluation: Purchaser contribute commercial information to the supplier evaluation and ranking systems (P1-MA). For important suppliers are even key supplier executives defined (M2-MA).

Change Management: Beyond the generic process is the negotiation and approval of technical changes a big part of the purchasing process (P2-MA).

Maturity of the Purchasing Process

According to the management, the maturity of purchasing in terms of digitalization is comparably high. Digitalization initiative are carried out and advanced systems are used (M1-MA, M2-MA). Diverging, purchasers report a high work load through system operations and processes that do not live up to their digital potentials (P1-MA, P2-MA).
Automations are still in the development phase (M2-MA, P1-MA). More operative areas already relying on EDI on the other side are already strongly automated (M3-MA, S1-S1A, S1-S2A).

Integration on the vertical level were recently improved through system integration of purchasing into the overall organization (M1-MA, M2-MA). Horizontal integration exists through B2B portals that are described to rather have a data sharing and documentation purpose (P2-MA, M2-MA, S1-S2A).

**Reshaped Purchasing Process:**

For the reshaped purchasing process, participants see the clear potential for the strategic purchasing process (M3-MA, P1-MA, M2-MA, P2-MA, S1-S1A, S1-S2A). Purchasers expect a structural change (P1-MA, S1-S2A), faster and more flexible processes (P1-MA), stronger integrating of related functions (S1-S2A) based on a holistic, fully integrated IT infrastructure that pre-assesses key data.

The operative purchasing processes is seen to be quite mature with less potential for adjustments (M3-MA, M1-MA, M2-MA). Further advancements are expected in relation to real-time data usage (M1-MA, M3-MA, S1-S2A, S1-S1A, P2-MA).
Case B

Influences Through Technologies

CPS: While none of the interviewees mentioned a direct influence of CPS on purchasing, the indirect influence was considered as relevant (P1-MB, OD, M3-MB, S1-SB, M1-MB). In this regard real time information sharing (M1-MB, M3-MB), capacity overviews (S2-SB, M1-MB), automatic processing of data (S1-SB, M1-MB), and removal of system interruptions (S1-SB, M1-MB) where mentioned. Nevertheless, the general influence was considered less than of IoT/IoS and Big Data/Business Intelligence (M1-MB, M2-MB, M3-MB, P1-MB, S1-SB, S2-SB).

IoT: In case of IoT the main influences were expected to be: (price) transparency (M3-MB, S1-SB, OD, M1-MB), data availability (S1-SB, M3-MB, P1-MB), easier data analysis (M1-MB) faster access to information (S1-SB, M3-MB), better communication (P1-MB, M3-MB), and removal of system interruptions (M1-MB, S1-SB).

Big Data/BI: Additionally, Big Data and Business Intelligence were also expected by the interview partners to strongly influence purchasing. In this context improved data collection (P1-MB, M2-MB, S1-SB, M1-MB) and making use of the increased amount of data by smart data analysis (P1-MB, M2-MB, S1-SB, M1-MB) were the main points mentioned. Besides that, holistic systems (P1-MB), enhanced transparency (P1-MB), and automation (M1-MB) were also mentioned.

Smart factory: There was not any influence of smart factory identified by the interview partners.

Influences Through Production

Two different types of production influence could be observed during the interviews, those of Industry 4.0 in the own production of the manufacturer and those of Industry 4.0 in the production of the supplier.

In terms of the own production the influences mentioned were more production related information for planning and analyzing (S2-SB, P1-MB, M3-MB), and a flexible demand driven production which requires more flexible ordering and suppliers (M1-MB, OD, P1-MB).
With respect to the supplier’s production the interview partners expect an increased transparency through real-time access of production data in terms of quality, production performance, production status, and capacities (S1-SB, M3-MB).

**Influences Through Changing Business Context**

The conducted interviews showed that some influence is expected through new products and smart products that are required by the customer. Nevertheless, this does not apply for all product types e.g. functional products (P1-MB, S2-SB). Based on this purchasing is also facing new suppliers in form of technology companies and start-ups.

Furthermore, due to the higher production flexibility that is expected and the possibility of technological support, some of the interviewed persons expect a change in pricing. Instead of today’s product based pricing, capacity agreements (M1-MB, S2-SB) or agreed cost parameters will form the price base for several different products (M1-MB).

All interviewees see a change in the purchaser’s role. The operative process will be highly automated (M1-MB, S2-SB, P1-MB, M3-MB) or according to some participants even carried out autonomously (P1-MB). Furthermore, administrative tasks and systems inputs will be reduced through better systems (M1-MB, M2-MB, M3-MB, P1-MB). This will change the purchasing function towards being more holistic and focus on strategic elements (M1-MB, S2-SB, M3-MB, M2-MB, P1-MB). The increased available of data will also require a stronger analytical focus (M1-MB, M3-MB). Furthermore, these changes also require digital trained and skilled employees with good data analysis skills that can cope with the new situation, which is seen as huge issue by several interviewees (M1-MB, M2-MB, M3-MB).

**Influences Through Changing Integration**

Horizontal integration between the automotive manufacturer and its 1st tier suppliers is considered as very important (M1-MB, S1-SB, P1-MB, M3-MB). While some participants also call for supply chain wide integration (M2-MB, M3-MB), one manager and the interview partners at the supplier point out that due to complexity, investment, and lacking skills this will be very difficult or even impossible (M1-MB, S1-SB, S2-SB). Through improved horizontal integration the interviewees expect: simplified and improved collaboration (P1-MB, S2-SB, M1-MB), process optimization (faster, reduction of redundant tasks) (S1-SB, P1-MB, M3-MB), joint/more transparent product development (S1-SB, M3-MB), less administrative tasks (S2-SB, P1-MB), easier communication (S2-SB, S1-SB, P1-MB), and
improved transparency with respect to real time access to production data, available capacities, and delivery status (M2-MB, M3-MB, S1-SB, P1-MB).

M1-MB also pointed out that increased integration not necessarily only brings advantages as it also increases the complexity.

End-to-end engineering was not considered as desirable or achievable by any of the participants.

Vertical integration is considered as less crucial for improvements than horizontal, but still expected to be positively influenced by Industry 4.0. The most crucial improvement is seen in better system linkage and removal of system interruptions (M1-MB, M2-MB, M3-MB). Furthermore, the better and faster availability as well as the automatic processing of internal data especially from sales and product development is seen as positive influence (M1-MB, P1-MB, S2-SB). This will lead to faster processes and better decision making (M1-MB, P1-MB).

**Current Purchasing Process**

*Define specifications:* Several different functions are involved in the define specification sub process. The most crucial interfaces are with the functional departments and the product development (M1-MB, P1-MB, M2-MB, M3-MB). The initial purchasing specification is created by the design/product development department and then checked by purchasing and supplemented by commercial terms (M3-MB, M2-MB). In some cases the purchaser is also already involved on an early stage of the specification defining (M2-MB, M1-MB). As confirmed from the manufacturer site as well as from the supplier site, in most cases the supplier is not involved in this process but only receives and considers the specification (S1-SB, P1-MB). No direct system support for purchasing does exist in this context.

*Supplier selection:* One of the core responsibilities of purchasers at manufacturer B is the supplier selection (P1-MB, M2-MB, M3-MB). The initial task is to prequalify suppliers that fulfill the internal and technical requirements (M1-MB, P1-MB). Based on this and in coordination with other purchasing units (Wolfsburg) the bidders list is created (M2-MB). Based on the bidders lists RFQs are send out through a B2B platform (M1-MB, M2-MB, P1-MB). In some cases e-auctions are used instead of RFQs (M2-MB, S2-SB). The supplier has to provide the offer in a predefined format including cost breakdowns to allow easy comparison and processing (M1-MB, M2-MB, P1-MB). Nevertheless, P1-MB points out that
these analysis forms are not standardized and differ between purchasing units. Based on the “quotation analysis forms” the offers are compared and suppliers are selected for further negotiation. The supplier is involved in this process by receiving the RFQ and offering accordingly (S1-SB, S2-SB).

**Negotiation and contracting:** The negotiation task is carried out in person between purchasing and the supplier and can also be seen as one of the core tasks of purchasers at manufacturer B (P1-MB, M2-MB, M3-MB). Besides prices, other elements such as quantities are negotiated (S1-MB). Contract agreements are prepared in coordination with the legal department (M1-MB). In most cases a frame contracts for the complete product life cycle is made (M1-MB, M3-MB). Nevertheless, not in all cases the contract lasts the complete life time (M1-MB). In some cases the contract already includes future price reductions in other cases annual price negotiations are taking place (S2-SB, P1-MB). In case of some strategic products manufacturer B is also negotiating with the sub supplier and by that pre-defines the supplier for their suppliers (M1-MB).

**Ordering:** Based on the RFQ and the agreed frame contract an initial order (blanket order) is created against which the future call-offs will be done (P1-MB, M2-MB, S2-SB). Only if this initial order is created in the system, call-offs can happen (S2-SB, P1-MB). Once conditions for the frame contract change, the initial order also needs to be changed (S2-SB). Call-offs are then executed by dispatchers at the production plant and send via EDI to the suppliers (M1-MB, P1-MB). Except for the initial order, this step is described as quite automated (M1-MB, M3-MB).

**Order follow-up:** While P1-MB sees order follow-up as one of the key responsibilities of purchasing, all other interviewees only see an involvement of purchasing in trouble shooting. All other tasks are considered to be the responsibility of logistics and operations (M1-MB, P1-MB, M3-MB, M2-MB). The majority of these tasks seem to be quite automated such as the material receipt (M1-MB, M2-MB).

**Evaluation:** Supplier evaluations are performed constantly based on past performance of deliveries and in consideration with all involved functions (M1-MB, M2-MB, M3-MB). The information are mainly collected automatically and no involvement of the supplier is required. Furthermore, performance information are forwarded to the suppliers (S1-SB).

**Change Management:** Additional to the generic process, change management is an important step of the purchasing process for manufacturer B. As outlined in the interviews, several
changes are required still after price agreement and nomination of supplier. Therefore, the respective changes need to be communicated with the selected supplier and prices changes accordingly. Due to the fact that a supplier is already selected and a contract agreement for that exists, these changes are producing quite high extra costs for manufacturer B as no real negotiation power exists at this stage anymore.

Furthermore, this process requires a lot of back and forth with the supplier as the changes new to be communicated, approved, and new prices advised. Right now no system support for this step exists.

**Maturity of Purchasing Process**

The maturity of digitalization was assessed quite different by the interview partners. While especially from the supplier side, digitalization was considered to be quite mature at manufacturer B, the interviewed persons at manufacturer B were having a more critical view. It was outlined that the automotive industry in general and manufacturer B in particular is quite ahead of others in terms of digitalization, but nevertheless is far away from making use of the full digitalization potential. B2B platforms for RFI and RFQ exist (S2-SB, S1-SB, P1-MB, M1-MB), e-auctions are considered in some cases (P1-MB, S2-SB), and some information (e.g. delivery status) are digitalized (M2-MB, M3-MB). Nevertheless, it was admitted that even though a B2B platform for interaction with the supplier exist, a lot of communication is still done by e-mails and excel lists (e.g. cost breakdowns) (S1-SB, P1-MB). The same applies for internal communication. Furthermore, specific supplier information still need to be collected manually and are not provided by the system P1-MB).

Automation is assessed as less mature than digitalization. Even though one manager claims that RFQ, Dataflow and ordering process are automated (M1-MB), a different picture was received from the remaining participants. The majority sees automation at a starting point right now (S1-SB, S2-SB, P1-MB, M2-MB, M3-MB). According to the interviewees, there exists already more automation in case of the operative process in comparison to the strategic process (S2-SB, P1-MB). Even though there is already some automatic exchange a lot of data still needs to be manually enter to a system, transferred from one system to another, call-offs need to be created manually in the system, and no automatic data processing exists (S2-SB, S1-SB, P1-MB, M2-MB).

On an organizational level the internal and external integration, with respect to communication and information exchange is seen as quite advanced S1-SB, S2-SB, M1-MB).
Nevertheless, it could still be further improved and especially simplified (M1-MB). Nevertheless, these integration is only limited to the supplier-manufacturer interface and not along the supply chain (S1-SB, S2-SB). As pointed out be the supplier during the interviews, there is also no desire from the supplier side to do so.

Contrary to that, the system integration is perceived to be on a very low level (M1-MB, S1-SB, S2-SB, M2-MB, P1-MB). Different systems that are not connected to each other exist for manufacturer B which results in system interruptions (M1-MB, P1-MB). Furthermore, these system interruptions can also be observed in connection to the supplier, as there exist no integration of the manufacturer and supplier system (M1-MB, S1-SB, S2-SB, P1-MB). On the supplier side data needs to be transferred manually from the own system into the B2B system of the manufacturer (S1-SB, S2-SB). The biggest improvement potential was seen in this context (M1-MB, P1-MB, S2-SB, S1-SB).

**Reshaped Purchasing Process**

For future improvement, high potential is seen in reduction of system interruptions and manual data transfer, automatic data processing and analyzing, and improved transparency. Through this, better information and planning are expected as well as the availability of pre-analyzed data for better decision making. Furthermore, the reduction of administrative tasks and the speed up of the purchasing process, especially with respect to the time until the SOP, are considered to be main advantages for the future.
Case C

Influences through technologies

CPS: The interviews showed that no direct influence of CPS on purchasing is expected. Nevertheless, an indirect influence is expected by three interviewees (P1-MC, P2-MC, S1-SC). Through CPSs in the production real time data exchange (P1-MC, S1-SC), process and capacity transparency (P1-MC), visibility of production statuses (P2-MC, S1-SC), and increased data access and quality are expected (P1-MC, P2-MC, S1-SC). According to P1-MC the exchange of the respective data consumes a lot of time right now and slows down the process. While for the purchasers at manufacturer C the access to the supplier’s production information was the core focus, for the sales representative at SUPPLIER C the production transparency of the customer was also an important element (P1-MC, P2-MC, S1-SC).

IoT: With respect to IoT the interviewees mentioned better connection and information exchange (P1-MC, P2-MC, S1-SC, S2-SC), both way communication (P1-MC, S1-SC), and easier supplier involvement and interaction (P1-MC, S1-SC). It is expected by the interview partners that IoT will improve collaboration (P1-MC, S1-SC).

Big Data/BI: Through Big Data and Business Intelligence, improved data availability and collection in combination with better data analysis is expected (S2-SC). In this context cost breakdown comparisons (M1-MC), analysis of different options by considering all possible factors (P1-MC, S1-SC), as well as collecting and analyzing data about capacities, processes and cost structures (P1-MC, P2-MC) were mentioned.

Smart factory: With respect to smart factories, only a small influence was expected. Through interlinkage of all production elements a production process transparency is expected by P1-MC, that can help to understand the production steps of the supplier and lead to a better planning and product development. Furthermore, S1-SC pointed out that through completely interlinked factories and companies a fully automated real-time ordering process, from the production of the automotive manufacturer into the production of the supplier would be possible.

Influences through production

The influence of the own production on purchasing is expected by manufacturer C to be quite low. Nevertheless, it needs to be mentioned that most of the interview partners also pointed out that due to the none existents of Industry 4.0 or Industry 4.0 considerations they cannot
adequately judge the influences it might have. The sales representative at supplier C nevertheless sees a positive influence that will occur through Industry 4.0 in their customer’s production. This is based on a better connection to the customer’s production and therefore improved planning, reduced stock levels, and reduced costs at the supplier side (S1-SC).

Considering Industry 4.0 based production at the supplier, one purchaser at manufacturer C sees an influence through the possibility of better connection and information exchange between the supplier and manufacturer with respect to production information (P1-MC). From the supplier perspective, the better internal availability of data to serve the customer’s needs is pointed out as well as making a fully automated ordering process from customer’s demands directly into own production possible (S1-SC).

**Influences through changing business context**

All interview participants pointed out that for their commodities (metal products) smart products and new technologies are not relevant. Furthermore, the relevance of smart products is considered to be in general less relevant for construction vehicle manufacturers than for car manufacturers.

Therefore, the relevance of new suppliers is also seen as quite low. Only one purchaser at manufacturer C could think about new suppliers in the Industry 4.0 context based on upcoming 3D printing technology which will lead to 3D printing suppliers, not only for prototyping but also serial production (P1-MC).

Through new technologies and smart systems, all interviewed persons at manufacturer C see the possibility of new costing and pricing approaches (M1-MC, P1-MC, P2-MC). Instead of the current individual product based prices, a change towards parameter based pricing for product categories is expected. Based on production steps, capacities, material prices as well as other factors the individual price of a product is determined based on a predefined price structure for those parameters (M1-MC, P1-MC, P2-MC). This change is considered as highly desirable but only possible with support of Industry 4.0 related technologies (M1-MC, P1-MC, P2-MC). As pointed out by M1-MC, this would also lead to completely different contracts e.g. capacity agreements (M1-MC).

For the purchaser role, an influence of Industry 4.0 is expected through reduced administrative tasks and a stronger focus on strategic elements (P2-MC, S1-SC). Resulting from this a focus on the 20% of products that are more complicated and create struggle is
expected (P2-MC). Furthermore, the operative process is expected by the sales representative of supplier C to be fully automated (S1-SC).

**Influences through changing integration**

One purchaser at manufacturer C (P2-MC) and the sales representative at supplier C (S1-SC) are expecting an improved horizontal integration on the 1st tier level through reduced system interruptions (P2-MC, S1-SC), better and faster information access (P2-MC, S1-SC), and joint product development (P2-MC).

The interview partners at the automotive manufacturer are not expecting a closer integration of 2nd tier and 3rd tier suppliers and also do not see this as desirable. Nevertheless, the sales representative at supplier C points out that a closer integration of the 2nd tier suppliers can be expected and also seen as beneficial. Nevertheless, S1-SC considers in this regard an automatic data transfer from the customer, through the own system to the suppliers. Consequently, the 1st tier supplier would stay the point of contact for the automotive manufacturer.

For the vertical integration, the only influence that could be identified was a joint interface for the product development process which not only enable supplier interaction but also of internal actors such as purchasing (P2-MC). Besides that, the vertical integration, mostly based on the SAP system, is considered to be at a high level where no further improvement through Industry 4.0 technologies is expected.

**Current Purchasing process**

*Define specifications:* For manufacturer C, the define specification sub process is mainly the responsibility of the R&D department/design engineers (M1-MC, P1-MC). Nevertheless, it also requires interaction with other actors, such as purchasing and suppliers. The determination of requirements is performed by the R&D department and then forwarded to the purchasing department (P1-MC). For the definition of the order specification, the purchaser is involved in the process and providing input e.g. about supply possibilities, but according to P1-MC and P2-MC has no influence on the specification and technical elements. P2-MC sees the main task of purchasing in this step in setting up the contact between engineering and the supplier. Consequently, a lot of communication is handled directly between engineering and supplier and purchasing is only taking a passive role in this. Even though there exists a system for the development process, this is not integrated in the overall
system (P2-MC). Furthermore, the definition of the purchase order specification requires a lot of documents exchange (e.g. drawings) right now, for which no system support exists (M1-MC, P2-MC).

Supplier selection: The interviewed purchasers and manager are all highly involved in the supplier selection process. This sub process is mainly involving purchasing, but to some extent engineering as well as the supplier are also involved (P1-MC, P2-MC). Engineering is involved in the prequalification of suppliers while the supplier is involved as a counterpart in several of the tasks. In the prequalification of suppliers task, suppliers are divided into four categories: preferred suppliers, back up suppliers, new suppliers, and phase out suppliers (P1-MC). This classification is based on the available information about the supplier as well as the companies performance and past experiences (P1-MC, P2-MC). Based on the classification of suppliers, suitable suppliers are selected by the purchaser in the system to whom a RFQ should be sent (M1-MC, P1-MC). Normally the RFQ is sent to 3-4 suppliers (P2-MC). The RFQ is sent out through the SAP system and suppliers are receiving an e-mail, which is informing them that an RFQ is available on the B2B platform of manufacturer C (M1-MC, P1-MC). The offers, together with cost breakdowns, are then placed in the B2B platform and based on this transferred to the SAP system of manufacturer C (P1-MC). Based on the received offers, the purchasers and manager are analyzing the received offers (M1-MC, P1-MC, P2-MC). According to M1-MC and P1-MC for this purpose the received data is transferred into Excel sheets to perform further analysis especially on cost breakdowns. As system support in this context the conversion of offers in different currencies into one defined currency (USD) to enable comparison is mentioned (P1-MC). Even though the offers are analyzed based on the offered prices, price is not the only selection criteria for the manufacturer (M1-MC, P1-MC). Other factors such as delivery times, product criteria, past performance, available capacities, and best practice in production with respective supplier are also considered (M1-MC, P1-MC, P2-MC).

Negotiation and contracting: This sub process is also described by the interviewees as the core tasks of the purchasing department (M1-MC, P1-MC, P2-MC). Based on the supplier selection final negotiations are executed for complex and important products while form simple, basic parts no further negotiations are performed as the effort is not justified by the possible advantage (P1-MC).
As for every prequalified supplier a general contract already exists with respect to basic conditions such as confidentiality, payment terms etc., the negotiation only involves part related issues such as price, delivery time and quality (M1-MC, P1-MC, P2-MC). Based on this, a second contract, the so called QDC agreement, is created (M1-MC, P1-MC, P2-MC, S1-SC). The contract details can be selected in the system and based on the RFQ directly be converted into a contract (M1-MC). The duration of a QDC agreement differs and depends on several factors e.g. time or raw material changes (M1-MC). According to S1-SC, these contracts also include some regulations on maximum deviation on schedules and forecast for the manufacturer. In most cases only one supplier is selected, but in case of high supply risk and long lead times, manufacturer C sometimes considers dual sourcing (M1-MC). Furthermore, manufacturer C only negotiates and has contracts with its 1st tier supplier and there exists no commercial involvement with sub suppliers.

Ordering: The interview participants at manufacturer C are only partially involved in this sub process. They are involved in the sample and prototype ordering, but once the serial production starts, which means the samples are approved and the PPAP (Production Part Approval Process) was successful, the responsibility is transferred to the logistics department at the respective plant (M1-MC, P1-MC, P2-MC). After successful approval process and before the serial production, an initial order is created in the system by the purchaser against which the production call-offs are then placed (P1-MC, P2-MC). The respective call-offs are then placed by the production of each plant and automatically created and send through the MRP via EDI to the supplier (M1-MC, P2-MC, S1-SC). At the supplier side, the received call-offs are then transferred into production orders (S1-SC). According to P1-MC and S1-SC this process can be considered as highly automated.

Order follow-up: For the order follow-up, purchasing is only involved in trouble shooting (M1-MC, P2-MC). Delivery time control is handled by the logistics department (M1-MC, P1-MC) while quality inspection is in the responsibility of the QA department (M1-MC, P1-MC). Quality inspections are only relevant for the initial delivery and are skipped for deliveries for serial production (M1-MC, P1-MC, P2-MC). The invoice handling is completely automated through EDI and only requires purchasers interaction in case of differences between the suppliers value and the value in the system (M1-MC, P2-MC).
Evaluation: The supplier evaluation and ranking is handled through an electronic evaluation tool which is fed with information by the SAP system (P1-MC, P2-MC). Delivery precision, quality, price level and many other factors are considered (P1-MC). New scores are provided every month and also shared with the suppliers (P1-MC).

Change Management: Additionally, to the generic process discussed with the interview partners, the relevance of change management for manufacturer C was also pointed out. Due to supplier selection and price agreement on an early development stage several changes are still necessary after nomination and contract agreement. This can be the case before the SOP or in some cases even after the SOP (P2-MC). As pointed out by P1-MC and P2-MC this leads to additional costs due to a reduced negotiation power. The change management process is performed quite manually and is not supported by the system.

Maturity of purchasing process

The digitalization of manufacturer C was considered by all interview participants, at the manufacturer as well as at the supplier, as quite mature. This is based on the fact that at manufacturer C SAP is introduced as company wide (M1-MC, P1-MC), B2B platforms are used for RFQ, sending out drawing, and receiving offers (M1-MC, P1-MC, P2-MC), and an intranet for internal information in which fields of interest can be set exists (M1-MC).

Nevertheless, it was also pointed out by the employees of manufacturer C that the complete potential of digitalization is not yet reached. They all mentioned that, there is still a lot of e-mail and personal information exchange, drawings and technical details are send back and forth with the supplier without using the system, and cost breakdown analysis and technical feedback are done in Excel. E-auctions are not used.

With respect to automation, a quite mixed picture can be drawn. On the one hand the usage of EDI automates the ordering and order follow-up process (M1-MC, P1-MC, P2-MC, S1-SC, S2-SC), call-offs are created automatically based on MRP (P1-MC, P2-MC), received orders at supplier C are automatically transferred in the own system and production planning (S1-SC, S2-SC), the supplier evaluation tool is automatically fed by the SAP system (P1-MC), and the SAP system automatically converts offers in different currency to one predefined currency (USD) (P2-MC).

On the other hand, for the strategic purchasing process, everything needs to be initiated in the system and no automatic data transfer happens (M1-MC), in a lot of cases the system still
needs to be fed by hand (M1-MC, P2-MC), suppliers are selected manually, and non-structured data exchange is not automatized yet (S2-SC).

The organizational integration, especially in the internal context, is considered to be already quite good (M1-MC). Even though manufacturer C is quite integrated with its suppliers (M1-MC, P1-MC, S1-SC), they are not too involved in 2nd or 3rd tier suppliers as they want to keep the responsibility with the 1st tier supplier (M1-MC, P1-MC).

With respect to the system integration it was mentioned that all plants of manufacturer C are linked by one system (SAP) and even though sub systems exist in different departments, they are linked to the system and can make use of the provided data (M1-MC). For the operative purchasing process, the system integration between supplier and manufacturer is considered as quite good due to the EDI connection (M1-MC, P1-MC, S1-SC, S2-SC). For the strategic purchasing process, an interface to the supplier exists in form of the B2B platform but no linkage exists with the supplier’s system (P2-MC, P1-MC, S2-SC). Furthermore, the supplier pointed out that right now it is rather a one-way communication from the manufacturer to the supplier and no interactive communication is possible (S1-SC, S2-SC).

With respect to system integration of sub suppliers, S1-SC points out that in case of the operative process, the manufacturer call-offs are automatically transferred into 2nd tier supplier call-offs based on system integration and underlying algorithms. The connection to the 2nd tier supplier nevertheless is then through Web EDI (S1-SC).

**Reshaped purchasing process**

For the reshaped purchasing context, the core changes are expected to occur for the strategic purchasing process, as the operative purchasing process is seen as already quite automated and consisting of little improvement potential (M1-MC, P1-MC, P2-MC, S1-SC, S2-SC).

For the strategic purchasing process the interviewees expect increased transparency (P1-MC, P2-MC), faster data access (P1-MC, P2-MC), better data analysis (M1-MC, P1-MC, P2-MC), eased price calculations (M1-MC, P1-MC, P2-MC), increasing automation (M1-MC, P1-MC, P2-MC), reduced process times (P1-MC, P2-MC), less system interruptions (P1-MC, P2-MC), and a closer supplier integration and interaction (P1-MC, P2-MC).

For the operative purchasing process, no changes where directly pointed out by the interview participants due to the already high level of automation and system integration.
Appendix B: Interview Guide

Introduction & Terminology

Purpose:
The purpose of this interview is to explore:
- The influence of Industry 4.0 on purchasing at automotive manufacturers
- How the purchasing process will be reshaped through Industry 4.0

Purchasing Process:
The underlying understanding of the purchasing process for this research includes the following sub processes:
- Define specification: determine purchasing requirements, develop purchase order specification
- Select supplier: prequalification of suppliers, RFQ, analysis of bids/quotations, select suppliers
- Negotiation and contract agreement: prepare contracts, negotiate contracts
- Ordering: placing order, create and send purchase order
- Order follow-up: delivery time control, trouble shooting, quality inspection, handling invoice
- Evaluation: supplier evaluation, supplier rating, supplier ranking

Industry 4.0:
Industry 4.0 can be described as industry transformation through digitalization and automation of production and linking in supply chains, enabled through internet and future-oriented technologies and smart systems.

Fundamental Technologies & Concepts of Industry 4.0:
- Cyber-Physical Systems: fuse the physical and the virtual world. This means, that computation and physical processes are integrated. Computer systems monitor and control the physical process with loops/effects from both computations and the physical process.
- Internet of Things, Data & Services: are interconnected IT systems that communicate and interact with each other and humans. IoT builds the network infrastructure for self-controlling smart objects.
- Big Data & Business Intelligence: Big Data describes wide ranging, complex structured, large data sets. In combination with Business Intelligence, valuable information can be extracted and mined to identify patterns/correlation producing valuable new knowledge.
- Smart Factories: are integrative factory systems with connected manufacturing resources, promoting a conscious and intelligent network which controls and maintains its own operations.

Business Implications of Industry 4.0:
- Industry 4.0 is not limited to advances in production but further reshapes linked business processes.
- Structures and technologies in purchasing are assumed to be strongly effected through Industry 4.0.
- Industry 4.0 promotes stronger horizontal integration, vertical integration and end-to-end engineering (cross-linking/digitalization throughout the entire product life cycle).

Purchasing 4.0 (preliminary working definition):
Purchasing 4.0 describes the highly automatized and digitized managing, planning and acquiring of external resources within an Industry 4.0 environment, enhanced by internet and future-oriented technologies as well as smart systems.


**Semi-Structured Interview Guide:**

**General & Personal Questions:**
G1) What is your current position? How would you describe your main responsibilities?
G2) How are your responsibilities related to the before-mentioned purchasing process?
G3) What is your purchasing/sales context?
G4) How mature would you assess your company’s purchasing practices in terms of digitalization, automation and integration?
G5) What do you see as challenges/problems automotive purchasing is facing right now?
G6) To what extent is Industry 4.0 considered in your company and how relevant is it for purchasing?

**Influence on Purchasing Process:**
I1) How do you think will Industry 4.0 in general influence the purchasing process?
I2) How do you think will Industry 4.0 in your company’s production influence the purchasing process?
I3) How do you think will fundamental technologies and concepts influence the purchasing process?

**Reshaping the Strategic and Operative Purchasing Process:**
R1) How do you think will the before-mentioned concepts/technologies as well as advances in integration the strategic purchasing process of automotive manufacturers?
R2) How do you think will the before-mentioned concepts/technologies as well as advances in integration reshape the operative purchasing process of automotive manufacturers?

**MANAGEMENT PERSPECTIVE:**
M1) What influence on the purchasing process do you see in terms of vertical integration?
M2) What influence on the purchasing process do you see in terms of horizontal integration?
M3) What influence on the purchasing process do you see in terms of end-to-end integration?
M4) How are Industry 4.0 related management/IT challenges (data security, standardization) addressed in your company?

**PURCHASER PERSPECTIVE:**
How do you think will the before-mentioned concepts/technologies as well as advances in integration (horizontal, vertical, end-to-end) reshape the sub process:
P1) … ‘define specification’?
P2) … ‘select supplier’?
P3) … ‘negotiation and contract agreement’?
P4) … ‘ordering’?
P5) … ‘order follow-up’?
P6) … ‘evaluation’?

**SALES PERSPECTIVE:**
S1) What influences do you expect to occur through Industry 4.0 implementations at your customers’ operations on your sales function?
S2) What influences do you expect to occur through own Industry 4.0 implementations on your sales function?
S3) How close do you collaborate with your automotive customers? Is there desire for closer collaboration?
S4) What influences do you expect to occur from a closer horizontal integration within your supply chain?
S5) What influences do you expect to occur from a closer end-to-end integration within your supply chain?
S6) How do you assess your company’s willingness/readiness to cope with Purchasing 4.0 implications?
S7) Do you see improved data sharing and real time access to information rather as a threat, challenges, or opportunity?

EXPERT PERSPECTIVE:
C1) What influence on purchasing in the automotive industry do you see in terms of vertical integration?
C2) What influence on purchasing in the automotive industry do you see in terms of horizontal integration?
C3) What influence on purchasing in the automotive industry do you see in terms of end-to-end integration?
C4) How can before-mentioned concepts/technologies reshape the purchasing sub processes at automotive manufacturers (define specification, select supplier, contract agreement, ordering, expediting, evaluation)?
C5) How do you assess the willingness/readiness of automotive manufacturers and suppliers to cope with Purchasing 4.0?
C6) How can automotive manufacturers cope with the Industry 4.0 related challenges (data security, standardization etc.)?

Closing Questions:
E1) What pre-requisites, barriers, and challenges do you see with respect to the implementation of Industry 4.0 and ‘Purchasing 4.0’?
E2) How do you see the role of your suppliers, IT department and consultancies concerning the change towards Industry 4.0 and ‘Purchasing 4.0’?
E3) Which major changes would you like to see with respect to Purchasing 4.0 in the future?
**Appendix C: Interview Participants**

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<th>Organisation</th>
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<td>Team Leader Purchasing</td>
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<td>Manufacturer</td>
<td>Buyer</td>
<td>P1-MC</td>
</tr>
<tr>
<td>C</td>
<td>Manufacturer</td>
<td>Purchaser</td>
<td>P2-MC</td>
</tr>
<tr>
<td>C</td>
<td>Supplier</td>
<td>Demand Manager</td>
<td>S1-SC</td>
</tr>
<tr>
<td>C</td>
<td>Supplier</td>
<td>IT Manager Sales Interface</td>
<td>S2-SC</td>
</tr>
<tr>
<td>Cross-case</td>
<td>Consultancy</td>
<td>Director</td>
<td>E1</td>
</tr>
<tr>
<td>Cross-case</td>
<td>Consultancy</td>
<td>Partner &amp; Managing director</td>
<td>E2</td>
</tr>
<tr>
<td>Cross-case</td>
<td>Institute</td>
<td>Head of research group ‘Purchasing’</td>
<td>E3</td>
</tr>
<tr>
<td>Cross-case</td>
<td>Consultancy</td>
<td>Consultant</td>
<td>E4</td>
</tr>
<tr>
<td>Cross-case</td>
<td>Consultancy</td>
<td>Associate Partner</td>
<td>E5</td>
</tr>
</tbody>
</table>
Appendix D: Consent Form

Interview Consent Form

Declaration:
I agree to be interviewed to provide an empirical foundation for the Master Thesis on Purchasing 4.0 composed by Simon Gottge and Torben Menzel under supervision of Professor Helena Forslund at Linnaeus University, Sweden.

I herewith certify that I was informed about the publication of the Thesis and am aware that the results will be shared with all research participants.

I hereby permit that (please mark corresponding boxes):
☐ The interview will be audio recorded
☐ Notes will be taken
☐ Notes will be shared with the supervisor and examination team
☐ My name will be mentioned
☐ My position will be described
☐ The organization’s name will be stated

Additional remarks by the interviewee:

..............................................................................................................................
..............................................................................................................................
..............................................................................................................................

________________
Name, Company, Date

Thank you very much for your participation in our research!

Simon Gottge & Torben Menzel