The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/1741-038X.htm

Relationship follows technology! How Industry 4.0 reshapes future buyer-supplier relationships

Johannes Wolfgang Veile and Marie-Christin Schmidt
Chair of Industrial Management,
Friedrich-Alexander University Erlangen-Nürnberg, Nürnberg, Germany
Julian Marius Müller
Salzburg University of Applied Sciences, Salzburg, Austria, and
Kai-Ingo Voigt
Chair of Industrial Management,
Friedrich-Alexander University Erlangen-Nürnberg, Nürnberg, Germany

Received 3 September 2019
Revised 9 December 2019
8 February 2020
27 April 2020
1 July 2020
Accepted 17 July 2020

Abstract

Purpose – This study analyzes how technological changes in the context of Industry 4.0 influence buyer-supplier relationships (BSRs).

Design/methodology/approach – The study is explorative in nature; hence, an empirical qualitative research design is applied. It bases on 45 expert interviews with managers from German and Austrian industrial companies as empirical data. A qualitative content analysis is conducted to inductively analyze the empirical material and to identify common patterns, themes and categories.

Findings – The paper finds that future transactions are mainly based on digitized, automated procedures, transferring various value creation processes to platforms. BSRs become more intense in nature. Companies consolidate their supplier base by focusing on important strategic suppliers.

Research limitations/implications – As the paper is of exploratory nature, it can only present first qualitative insights. Further studies can extend the results by analyzing and contrasting BSRs in various industries or value chain stages and map differences and similarities, respectively.

Practical implications – The paper's results provide implications for management and corporate practice alike. These help companies to raise Industry 4.0's full potential as for BSRs creating and securing long-term and sustainable competitive advantages.

Originality/value – This paper is among the first to empirically investigate BSRs in the context of Industry 4.0. Providing implications for research and corporate practice, it contributes to tapping Industry 4.0's full potential complementing an extra-organizational perspective.

Keywords Buyer-supplier relationships, Supplier relations, Industry 4.0, Industrial Internet of Things, Supply Chain Management

Paper type Research paper

1. Introduction

Industry 4.0 not only affects individual companies but also implies an interconnection across companies in value chains and value creation networks, asking for comprehensive data collection, processing and analysis (Barreto *et al.*, 2017; Bienhaus and Haddud, 2018; Tjahjono *et al.*, 2017; Tu, 2018; Wu *et al.*, 2016). As a result, data can be shared across companies, blurring corporate boundaries. Thereby, digital technologies act as integrative mechanisms, changing buyer-supplier relationships (BSRs) and creating new forms of cooperation (Ghadge *et al.*, 2020; Kagermann *et al.*, 2013; Obal and Lancioni, 2013). The complexity of BSRs is expected to increase in Industry 4.0 (Kagermann *et al.*, 2013; Obal and Lancioni, 2013). Competition of individual companies will transform into competition between value creation networks, which requires intensive cooperation in BSRs (Porter and Heppelmann, 2014).

So far, research scarcely analyzes BSRs in Industry 4.0, with a complete absence of empirical work, especially regarding the interconnection of companies, shared value creation

Journal of Manufacturing Technology Management

1741-038X
DOI 10.1108/JMTM-09-2019-0318

and cross-company organization and the differences to the status quo (Ben-Daya *et al.*, 2019; Haddud *et al.*, 2017; Tjahjono *et al.*, 2017). Only recently, research has turned its focus to Supply Chain Management (SCM) in Industry 4.0 at all and thus there is a paucity of studies (e.g. Abdel-Basset *et al.*, 2018; Bag *et al.*, 2018; Calatayud *et al.*, 2018; Legenvre *et al.*, 2020). So far, research either focuses on information and communication technology (e.g. Dedrick *et al.*, 2008; Thun, 2010; Vanpoucke *et al.*, 2017) or analyzes particular Industry 4.0 technologies for example the Internet of things (IoT), cloud computing and Big Data Analytics in SCM (e.g. Abdel-Basset *et al.*, 2018; Ben-Daya *et al.*, 2019; Gottge *et al.*, 2020; Manavalan and Jayakrishna, 2019) neglecting Industry 4.0's comprehensive nature and wide-ranging technological and strategical interrelations. Further, academia has concentrated on holistic research subjects such as supply chains (SCs) (e.g. Büyüközkan and Göçer, 2018; Calatayud *et al.*, 2018; Papert and Pflaum, 2017) and particular SCM functions such as procurement or logistics (e.g. Bienhaus and Haddud, 2018; Gottge *et al.*, 2020; Hofmann and Rüsch, 2017; Legenvre *et al.*, 2020). Hence, an analysis of the dyadic cooperation and BSRs at the nexus of Industry 4.0 and how they change from a holistic perspective is lacking.

However, analyzing BSRs in the context of Industry 4.0 is of particular relevance for several reasons from both a research and practice perspective. First, the cross-company interconnection of companies in a value chain represents a central element of Industry 4.0 (Büyüközkan and Göçer, 2018; Kagermann *et al.*, 2013). Thus, only through successful cooperation between companies, Industry 4.0's potential can be exploited in its entirety. Second, BSRs potentially represent a major source of future competitive advantage. Given a decreasing depth in value creation along with an increasing proportion of external procurement, suppliers are gaining in importance which in turn provides large opportunities for cost savings, especially in the context of Industry 4.0. In addition, suppliers do not only significantly influence buyers' production costs but also product quality and eventually the ability to supply (Gottge *et al.*, 2020; Müller *et al.*, 2020; Obal and Lancioni, 2013; Osmonbekov and Johnston, 2018; Thun, 2010). Third, since BSRs are closely interconnected with organizational structures, analyzing cooperation becomes crucial for their further development (Vanpoucke *et al.*, 2013; Wiengarten *et al.*, 2016). Figure 1 highlights the research gap this paper addresses.

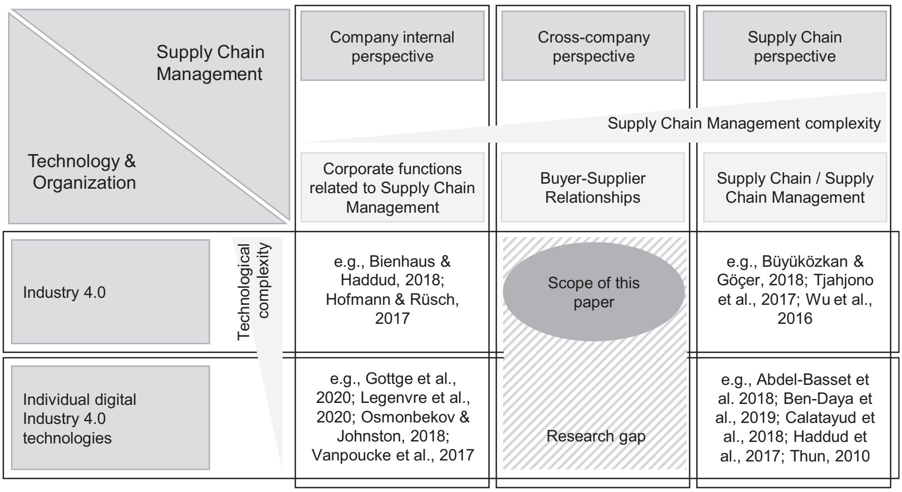

Figure 1.
Research gap and scope of the paper

Given the research gap, our study sheds light on BSRs in the context of Industry 4.0. In order to retrieve a comprehensive picture, we analyze BSRs at a well-advanced Industry 4.0 level and compare them with the status quo, following common research practice (e.g. Ghadge *et al.*, 2020). The study increases the understanding of BSRs' dynamics and characteristics in the context of Industry 4.0 addressing the following research question:

RQ1. What are the distinct characteristics of BSRs in the context of Industry 4.0?

After shedding light on "how" BSRs in Industry 4.0 differ compared to the present BSRs, we focus on "why" these changes occur to understand the underlying mechanisms and constituting determinants. Subsequently, we analyze the following research question:

RQ2. What are the drivers and causes for the transformation of BSRs in the context of Industry 4.0?

The remainder of this paper is organized as follows: Section 2 presents the theoretical background, followed by the method in section 3. Section 4 presents the results, which hereafter are discussed in section 5. Finally, section 6 concludes the paper with theoretical and managerial implications and suggestions for future research.

2. Theoretical background

Industry 4.0 represents a paradigm shift based on the digitalization and interconnection of industrial value creation. It is characterized by a seamless merging and extensive interconnection of the physical and virtual worlds, mainly based on cyber-physical systems and on the IoT (Kagermann *et al.*, 2013). Given its digital and interconnecting character, the full potential of Industry 4.0 cannot be leveraged when being solely implemented in isolated, company-specific solutions (Kagermann *et al.*, 2013; Müller *et al.*, 2018; Veile *et al.*, 2019). In turn, a comprehensive horizontal and vertical interconnection is the key to successfully implement Industry 4.0 especially across value chains (Ghadge *et al.*, 2020; Kagermann *et al.*, 2013; Wu *et al.*, 2016).

Representing the smallest object of reflection in SCM, the dyadic, long-term cooperation between a buyer and supplier is referred to as BSR (Vanpoucke *et al.*, 2013). BSRs may generate sustainable competitive advantages by creating and maintaining close cooperation, by combining resources and capabilities to realize joint activities and by aligning strategies (Vanpoucke *et al.*, 2013; Wiengarten *et al.*, 2016). These exceed mere contractual relationships, because they are subject to strategic planning and include multiple interdependencies between participating companies. Buyers and suppliers draw mutual benefits from close BSRs (Bienhaus and Haddud, 2018; Büyüközkan and Göçer, 2018; Haddud *et al.*, 2017; Vanpoucke *et al.*, 2017). Among other things, closely working together reduces costs, improves responsiveness, increases the service level, facilitates decision-making and increases efficiency, flexibility and agility (Bienhaus and Haddud, 2018; Dweekat *et al.*, 2017; Lee *et al.*, 2004). As companies tend to focus on their core competencies, the value creation depth has been reduced significantly (Vanpoucke *et al.*, 2013). For this reason, suppliers take on a growing part of value creation emphasizing the future importance of cooperation (Kagermann *et al.*, 2013; Müller *et al.*, 2018).

Industry 4.0 and underlying technologies like the IoT, Big Data Analytics and cloud computing serve to optimize individual BSRs and entire value chains in SCM, interconnecting multiple companies, production facilities and processes (Bienhaus and Haddud, 2018; Büyüközkan and Göçer, 2018; Dweekat *et al.*, 2017; Tjahjono *et al.*, 2017). Industry 4.0 enhances the communication in BSRs and allows sharing strategic and operative information on production, finance, research and development and competition in real time (Büyüközkan and Göçer, 2018; Dweekat *et al.*, 2017; Hofmann and Rüsch, 2017). Superior information exchange and further cooperation increase responsiveness, facilitate decision-making, improve service and product offerings' quality and improve operational and eventually business performance (Dweekat *et al.*, 2017; Vanpoucke *et al.*, 2017). By generating, processing and visualizing data, Industry 4.0 technologies can be used to coordinate and align planning and processing, and efficiently managing spare parts handling, procurement and warehousing (Bienhaus and Haddud, 2018). This results in an amplified transparency and resource efficiency of the value creation process (Dweekat *et al.*, 2017; Kiel *et al.*, 2017; Vanpoucke *et al.*, 2013). The interconnection and global orientation of activities open up possibilities for integrating external knowledge and increasing innovation capacity, for instance, by data backflow from products in use to product development (Kagermann *et al.*, 2013; Porter and Heppelmann, 2014). Automation, interconnection and the use of smart products pave the way for ubiquitous traceability of objects and predictability, thereby leading to increased robustness, flexibility and agility (Manavalan and Jayakrishna, 2019). To efficiently exploit advantages of a digital and interconnected value chain, cooperation is necessary not only with first-tier suppliers, but with all suppliers of the upstream value creation process (Dweekat *et al.*, 2017; Manavalan and Jayakrishna, 2019; Wu *et al.*, 2016). This can be supported by means of digital platforms, which are expected to take a key role for buyers and suppliers cooperating in Industry 4.0 (Gottge *et al.*, 2020; Kagermann *et al.*, 2013; Osmonbekov and Johnston, 2018).

So far, Industry 4.0 is neither fully applied in dyadic BSRs nor implemented throughout entire value chains yet, which prevents the unfolding of its full potential (Müller *et al.*, 2018). Aside from a lack in practical implementation, research studies at the intersection of SCM and Industry 4.0 have neglected BSRs. They either focused on specific corporate SCM functions (e.g. Bienhaus and Haddud, 2018; Hofmann and Rüsch, 2017; Legenvre *et al.*, 2020) or on holistic research objects like SCM in general and SC (e.g. Büyüközkan and Göçer, 2018; Calatayud *et al.*, 2018; Papert and Pflaum, 2017). It is without saying these analyses are appreciated but they entail shortfalls: Setting the focus on intra-company SCM functions does not go far enough and misses the perspective of the corresponding counterpart, i.e. the buyer or supplier. By contrast, analyses from a holistic SC perspective discuss a rather abstract level and neglect that dyadic BSRs represent its core missing a specific link to the smallest unit of consideration. Besides, academia in the SCM area has mostly regarded single Industry 4.0 technologies (e.g. Abdel-Basset *et al.*, 2018; Ben-Daya *et al.*, 2019) instead of Industry 4.0 from a general perspective. These approaches do not take into account that Industry 4.0 technologies are characterized by various dependencies and interactions, and that only taken together, the change in paradigm can be fully grasped and comprehensively understood. Hence, a specific consideration of BSRs and how they change in the era of Industry 4.0 is lacking. This research gap calls for an analysis of BSRs in Industry 4.0 from a SCM lens that is the motivation for our study.

3. Methodology

3.1 Research design and sample

The study addresses the research questions, how BSRs are characterized in the context of Industry 4.0 when compared to the present and which drivers and causes can be identified for the transformation.

The study applies a qualitative explorative empirical research design based on inductively analyzed in-depth expert interviews. Exploratory and qualitative research methods are used in contexts of complex, novel, evolving and contemporary phenomena, which are to be studied within their real-life environment (Edmondson and McManus, 2007; Eisenhardt and Graebner, 2007). This applies to Industry 4.0 and its concomitant effects on BSRs and therefore calls to use this research design.

Insights from 45 German and Austrian companies form the study's primary source of empirical data. Analyzing companies from Germany and Austria is particularly suitable for several reasons. First, these countries are rather homogeneous in terms of economy, history, culture and language and represent a major part of the German-speaking population. Second, these economies are of major economic importance within the European Union and at the same time have a representative character for developed and industrialized nations. Third, German and Austrian companies bare a great deal of experience regarding Industry 4.0 and their governments actively support these developments (Kagermann *et al.*, 2013).

The sample comprises a heterogeneous set of companies from different industry sectors and firm sizes. Among others, the companies stem from the following industries: automotive ($n = 6$), automotive suppliers ($n = 12$), consumer goods ($n = 4$), electronic and electrical engineering ($n = 9$), mechanical engineering ($n = 11$) and raw materials processing ($n = 3$). These industry sectors were chosen because of their leading roles in Industry 4.0. As far as company size is concerned, the sample companies vary in terms of sales volume (av. = 32,500 million EUR) and number of employees (av. = 90,000). The sample's heterogeneity and multidimensional perspectives enable a generalization of results and counteracting potential negative effects of sample biases (Edmondson and McManus, 2007; Eisenhardt and Graebner, 2007). Figure 2 summarizes the characteristics of the sample.

All companies were analyzed in their role as buyers for three reasons: First, buyers hold a strong position in the market and thus are able to influence the relationships to their suppliers. Second, they profit more from the transformation that in turn increases their efforts and commitment (Vanpoucke *et al.*, 2017). Third, Industry 4.0 necessitates high investments, for example as for infrastructure and systems, requiring a tremendous capital basis. In contrast to suppliers that often are small and medium-sized enterprises (SMEs), buyer-companies are usually of larger sizes and may already have achieved an advanced stage in implementing Industry 4.0 solutions (Müller *et al.*, 2018). When analyzing the relationships to their company's suppliers, the experts were asked to refer to their most important strategic suppliers in terms of strategical relevance, sales volume and duration of relationship. The analyzed BSRs include products of all product life cycle stages. In addition, the products purchased by the sample companies vary as for their stage in the customer order decoupling point and their level of customization.

We conducted semi-structured interviews with 45 experts in the sample companies. The nature of this interview method enables collecting data in a structured way while maintaining the required level of openness to allow unexpected and novel knowledge to emerge (Gioia *et al.*, 2013). The interview partners were chosen and subsequently serve as experts because of their professional knowledge and experience (e.g. in Industry 4.0, SCM and strategy) and their relevance (e.g. hierarchal level and company tenure). All experts hold lower, middle or top management positions in the areas of SCM, procurement, purchasing and logistics, respectively. The experts' industry experiences range from one to 39 years (av. = 10.27 years)

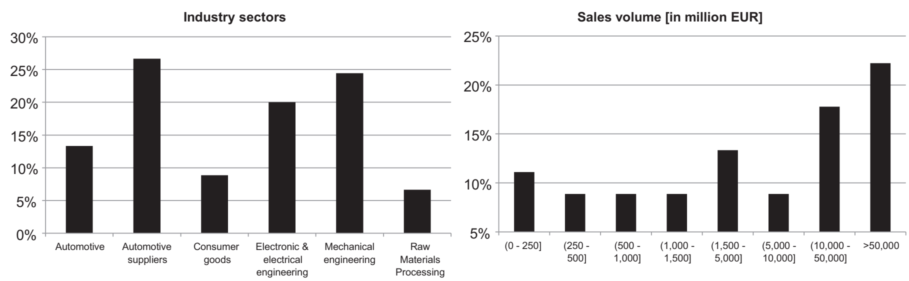

Figure 2.
Data sample characteristics

and their company tenure varies from one to 39 years (av. = 8.64 years). All experts are closely involved in or responsible for Industry 4.0 projects and have a profound knowledge of external markets and their respective company's strategy. Verifying the selection of competent and knowledgeable experts strengthens the validity and reliability of our findings (Eisenhardt and Graebner, 2007). The interviews took place between August 2018 and February 2019 and lasted between 22 and 99 min. In order to avoid language or cultural barriers and to ensure comparability, all interviews were conducted in German, the native language of the experts and interviewers. For confidentiality reasons, the experts' names and companies are anonymized (see Table A1). Choosing adequate experts, confidentially treating their statements and assuring them full anonymity, addresses potential key informant and retrospective biases (Edmondson and McManus, 2007; Eisenhardt and Graebner, 2007).

3.2 Interview guideline, qualitative content analysis and coding procedure

Given the exploratory nature of this study, the interview guideline was informed by literature while following the principles of openness and flexibility, thus unexpected and novel topics could be collected (Gioia *et al.*, 2013). In order to verify the guideline's execution duration, comprehensibility, structure, validity and informative value, a pretest with four experts was conducted. The final interview guideline can be found in Appendix 2.

All interviews were audio recorded and transcribed and subsequently examined applying a qualitative content analysis (Miles and Huberman, 1994). Transcribing the audio files revealed more than 640 pages of text material that form the primary data basis. Two researchers individually translated the German transcripts into English. This approach made sure the empirical material is properly transferred into English taking into account language meta-level, colloquial language and language nuances. From now on, the coding procedure and analysis were exclusively conducted in English.

A qualitative content analysis was used as it allows analyzing the empirical text material in a systematic and transparent manner, in order to identify patterns, themes and categories, which answer the research questions (Miles and Huberman, 1994). The developed categories were partly enriched with literature, however, the study follows an inductive coding procedure (Gioia *et al.*, 2013; Krippendorff, 2013) in order to allow new aspects and concepts to emerge (Eisenhardt and Graebner, 2007). By identifying consistencies and common patterns in the empirical data, inductive coding facilitates theory building (Edmondson and McManus, 2007). As for the coding procedure, the study at hand follows the renowned and widely appreciated procedure of Gioia *et al.* (2013): In a first step, first-order (informant-centric) categories were developed. Subsequently, the developed categories were synthesized into second-order themes. In a last step, the themes were distilled into general dimensions. The first-order concepts, second-order themes and the aggregated dimensions are depicted in Table A2 making the coding procedure and results transparent (Gioia *et al.*, 2013).

To increase validity and objectivity of the coding procedure, the process was conducted in a research team comprising of three authors (Gioia *et al.*, 2013). Coding in a team allowed us to constantly check, discuss and where applicable, modify the coding procedure. First, the individual authors separately suggested coding categories. Having done so, inter-coder reliability was found to be on a good level proving the validity of our coding procedure (Holsti, 1969). Second, individual coding was compared, carefully discussed and if necessary revised. Third, individual coding results were then consolidated and transferred into the final data scheme.

4. Empirical findings

In the following, the empirical results and interpretations are presented. Figure 3 presents the consolidated results (see Table A1 for complete table of results). Hereby, the numbers in brackets depict the frequency of how many experts (out of 45 experts) have discussed themes related to the respective code.

First, the paper shows how present BSRs are designed and how they are characterized respectively (section 4.1; left column in Figure 3). Thereafter, the paper identifies why BSRs are reshaped in the context of Industry 4.0 presenting drivers and causes for the transformation (section 4.2; middle column in Figure 3). Subsequently, the paper explains BSRs in the context of Industry 4.0 revealing differences in comparison to the present situation (section 4.3; right column in Figure 3).

4.1 Present buyer-supplier relationships

As for present BSRs, our empirical results show several framework conditions that determine relationship intensity (discussed by 27 out of 45 experts). Among others, framework conditions such as the type of supplier ($n = 22$) and product and sales volume ($n = 8$) determine how companies shape the relationships. Depending on the type of supplier and its relevance for the customer company just as the purchased products and product volume, the *relationship of trust*, the *way of communication* and the *frequency of communication* vary significantly.

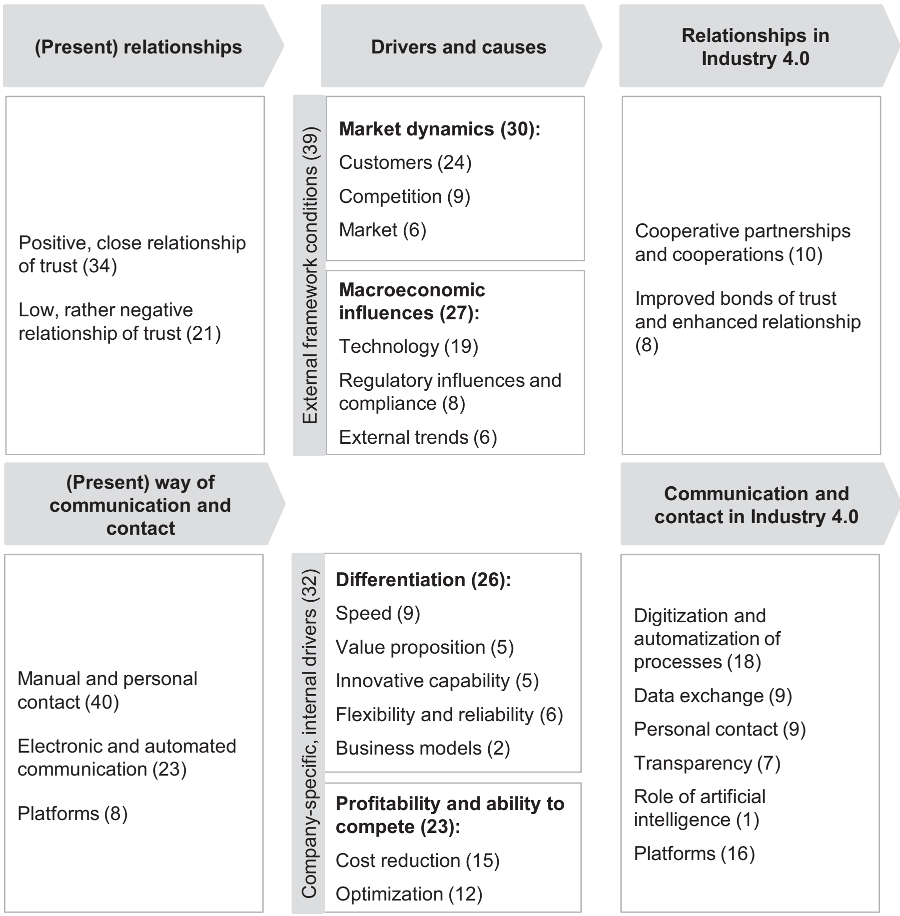

Figure 3.
Consolidated results

Relationship of trust plays a vital role in present BSRs ($n = 42$), since the sample companies maintain a positive and close relationship to their most important suppliers, in terms of high volume of purchased products and high strategic importance that is hard to replace. These relationships are characterized by a common philosophy and trustful and partner-like interactions. Further, such relationships are long-term and end-customer oriented and include common planning and research and development activities. Depending on the framework conditions, however, some BSRs are rather based on a low level of trust, which is especially true for standardized products where suppliers can easily be replaced. These relationships are mostly driven by price, costs and volume, hence keeping the focus on efficiency. The sample experts state, such relationships are part of a multi-sourcing strategy and are characterized by distrust, control efforts and short-term duration.

Furthermore, BSRs differ as for *communication and contact* ($n = 40$). In the present, communication is typically based on manual and personal contact. Analog, manual and non-automated processes characterize the current way of communication. The companies mainly interact through communication media and forms, such as, telephone, e-mail, telefax, events, meetings and face-to-face contact. Personal and manual contact is mainly used for highly individualized products, if technical communication equipment is missing, especially for the purposes of negotiating contracts, discussing special topics and dealing with any kind of deviation. This is also true if a purchased product is in the beginning of its product life cycle because in this phase, systems are far from being established with many deviations occurring. In addition, 23 sample companies already use electronic and automated forms of communication. For instance, in some areas they have automatized and digitized data transmission, cross-company processes and communication. These companies strengthen the supplier interconnection within their value creation processes. A small minority of eight companies use platforms maintaining platform-based processes and exchanging information, products and services via platforms.

> During the initial cooperation phase, there is a lot of personal face-to-face contact and contact via telephone. In the following, the contact frequency drops. However, we personally get in contact with the suppliers in case of problems, for instance, if certain deadlines are not met or if problems as for quality arise. (Interview No. 6)

Finally, the *frequency of communication* determines current BSRs ($n = 28$). When communication and contact are mainly based on manual and personal interaction, the frequency of buyer-supplier contact is rather high. 23 companies are in contact with their suppliers on a daily, weekly, or monthly basis or they did not specify their contact frequency stating, for instance, "continuous" or "regular". Nevertheless, 14 companies have a low contact frequency affirming they are in contact with their suppliers on a quarterly, half-yearly or annual basis. This holds especially true for electronic, digitized and automated interaction forms, because therein, contact is only required in case of (framework) changes or deviations.

4.2 Drivers and causes for the transformation

The reasons for BSRs to change in the context of Industry 4.0 can broadly be subdivided into *external framework conditions* ($n = 39$) and *company-specific, internal drivers* ($n = 32$).

As far as *external conditions* are concerned, *market dynamics* are crucial ($n = 30$). Predominantly, customers and their needs are decisive drivers. For instance, customer needs increase regarding individuality and quality of products, process transparency, flexibility and reliability. Competition represents an additional driver, given, e.g. aggressive competitors, new market entrants and difficult product differentiation. Last, market aspects are key, such as, increasing market dynamics.

> Customers determine the organization of the value chain all the way to the last supplier. In the end, customers must be willing to pay for the value offer and they must perceive an added value therein. (Interview No. 21)

Macroeconomic influences are further external drivers ($n = 27$). At first, technology pushes the transformation, for instance, as it provides the technical basis for real-time data exchange and Big Data analyses and as the costs for technical solutions drops significantly. Besides, regulatory influences and issues of compliance require reshaping relationships, e.g. regulations as for traceability of parts, statutory disclosure duty and environmental matters. Additionally, external trends, among others, a shortage of specialists and an increasing complexity of global value chains, forces companies to rebuild relationships.

> For our BSRs, the four technologies artificial intelligence, quantum computing, additive manufacturing, and virtual/augmented reality are of utmost importance and shape our future value creation network. (Interview No. 1)

As far as *company-specific, internal drivers* ($n = 32$) are concerned, one can distinguish between several further motives. Reshaping BSRs represents a way to *differentiate from competitors* ($n = 26$). First, processes and transactions can be accelerated, e.g. via shorter delivery times, faster reaction times and quicker time-to-market. Second, value propositions can be improved increasing customers' willingness to pay, e.g. offering hybrid product-service bundles and refining quality. Third, working closer together with upstream value creation stages enhances the ability to innovate, for instance, as it paves the way for supplier innovations. Fourth, process and transaction flexibility is strengthened and so is reliability. Last but not least, transforming BSRs may provide the basis for new business models to emerge.

> Another driver is that processes may become much faster. In our company, it takes a good three-quarter of a year from the very beginning of the product development to a product's market readiness. Closer cooperation with suppliers as for demand planning and conception would, on average, save at least a month. (Interview No. 19)

Striving for profitability and strengthening the *ability to compete* are further internal drivers ($n = 23$), as Industry 4.0 helps to decrease costs, among others, by paring down personnel, decreasing process complexity and reducing coordination efforts. Reshaping BSRs may optimize value creation processes, e.g. increasing process efficiency, reducing coordination needs and improving resource allocation.

Finally, strengthening buyer-supplier cooperation serves to increase *cross-company transparency* ($n = 9$). For instance, information transparency may decrease incorrect deliveries and storage volatilities. Besides, risks can be lowered establishing risk prevention and management measures across company borders.

4.3 Buyer-supplier relationships in Industry 4.0

Our empirical results reveal that Industry 4.0 has a *great impact* on BSRs ($n = 37$).

> We are still far at the beginning of the development towards Industry 4.0. [. . .] In the future, however, it will become a major driver of change in the area of SCM. (Interview No. 9)

In the context of Industry 4.0, BSRs get *more intense* ($n = 16$). This is based on improved bonds of trust and an enhanced relationship caused by close forms of cooperation, an increasing reliability and long-term oriented partnerships. Cooperative partnerships and cooperation will be predominant. For instance, these forms are characterized by providing Industry 4.0 implementation support and common problem solving. Apart from this, the *cooperation with suppliers* will be accelerated which is true for both system and processes and integration in research and development activities.

In the future, there are many suppliers with whom the relationship will become more intense given an increasing product complexity and variant diversity. (Interview No. 3)

A *supplier base consolidation* is expected in the future ($n = 11$). This is partly caused by a reduction of the supplier quantity, e.g. because some suppliers may not meet technological requirements. Likewise, companies rather tend to concentrate on strategic suppliers to realize further economies of scale and scope and as Industry 4.0 technologies require amortizing high investments.

Processes and transactions between buyers and suppliers will become *digitized and automatized* ($n = 33$). This is especially true for operative processes, such as, sourcing, negotiating, purchasing and ordering, for products that are at a rather mature stage of their life cycle and for rather low customized products. The results indicate that the cooperation intensity between buyers and suppliers and the level of trust will be further influenced by product complexity. Components with high degrees of standardization, rather low complexity and value that can be produced on stock will be purchased on a multi-source strategy maintaining a rather loose relationship to suppliers. In contrast, components of higher complexity, such as cyber-physical systems, require closer relationships between buyers and suppliers. Systems and interfaces are prepared to allow direct and real-time data exchange ensuring data and process transparency. Thereby, it becomes important to determine a solid and comprehensive strategical framework that defines the area of automatized transactions. Deviation management and personnel contact will only be necessary in exceptional situations and escalations. Artificial intelligence will play a more important role in the future.

In five to ten years, we will no longer have an operative purchasing department, but we will negotiate framework conditions on a strategical level while systems execute the operational processes in an automated and digital manner. (Interview No. 41)

In addition to current platform users, further companies will transform their value creation process onto *platforms* ($n = 16$). Using a platform allows interconnecting various isolated systems and applications of several actors. A platform increases the level of automation and digitization, e.g. for tendering processes. Besides, a platform enables to smoothly exchange data between companies maintaining data transparency, e.g. for forecasts, production planning and stocks.

In the industrial sector, procurement will most likely be conducted via platforms, just as you order and buy a book on an internet platform in the private world today. (Interview No. 34)

The *role of human workforce* is about to change as well ($n = 8$). Personal and manual contact will still be important, e.g. when it comes to decision-making. However, human tasks will mainly deal with strategical and monitoring activities. Especially for the aforementioned products of high complexity and low level of standardization, just like for products in their design phase before the actual serial production, personal contact will remain important. Accordingly, manual, operative and administrative activities will decrease significantly.

5. Discussion

This paper analyzes BSRs in the context of Industry 4.0 and how relationships are transformed by technological changes. Key findings obtained in the qualitative-empirical analysis include that Industry 4.0 influences BSRs in several ways. For instance, the results reveal that digitized, automated processes characterize future relationships along with an increasing usage of platforms (Gottge *et al.*, 2020; Osmonbekov and Johnston, 2018; Schmidt *et al.*, 2019; Thun, 2010). Relationships between buyers and suppliers become more intense, especially for complex, non-standardized products just like products at the beginning of their life cycles (Olhager, 2003; Wikner and Bäckstrand, 2018). Further, a consolidation in the supplier base is observable following the introduction of Industry 4.0, as indicated in our analysis, extending studies on the consolidation of the supplier base and risk management (Thun, 2010; Wiengarten *et al.*, 2016).

5.1 Close BSRs will further intensify through Industry 4.0

Referring to the results regarding current BSRs (section 4.1), several sample companies maintain a rather positive and close relationship of trust to their major suppliers and our results show that these kinds of relationships will further advance in the context of Industry 4.0. This bases on improving bonds of trust and enhanced relationships, cooperative partnerships and further cooperation (Kiel *et al.*, 2017; Vanpoucke *et al.*, 2013). The results empirically extend studies that expect companies to cooperate and interact closely with suppliers (e.g. Vanpoucke *et al.*, 2013; Thun, 2010).

BSRs in Industry 4.0 (section 4.3) are expected to be characterized by a further cooperation with suppliers both on an operative and strategic level creating multiple interdependencies between companies (Vanpoucke *et al.*, 2013; Wu *et al.*, 2016). Future supplier integration goes beyond the status quo scope leading to a holistic integration in various dimensions (Büyüközkan and Göçer, 2018; Haddud *et al.*, 2017). This includes a comprehensive system and process integration and further integration in research and development activities (Villena *et al.*, 2010). The study's empirical results confirm that the developments following Industry 4.0 pave the way to further integrate suppliers and thus lead to new forms of cooperation (Obal and Lancioni, 2013). Especially SMEs will have to be regarded in a distinct way, as their trust toward larger companies and doubts about the benefits of Industry 4.0 are to be integrated in the strategies and transformation processes toward future BSRs (Müller, 2019; Müller *et al.*, 2018).

5.2 Cooperation in loose BSRs will decrease leading to a supplier base consolidation

The paper finds that several companies maintain a loose, rather negative relationship to some of their current suppliers, focusing mostly on price, cost and volume, dependent on the type of supplier, the product life cycle stage and the level of customization (section 4.1). The experts postulate, companies lower their number of suppliers refraining from cooperation with non-strategic suppliers while concentrating on their most important strategic suppliers (Dedrick *et al.*, 2008; Wiengarten *et al.*, 2016). This goes in hand with intensifying and increasing cooperation with the remaining suppliers averagely improving BSRs. Regarding Industry 4.0, the dependence on key and system suppliers is to be augmented, especially for traditional manufacturers (Kiel *et al.*, 2017).

5.3 Nature of contact in BSRs and changes of humans' roles

As revealed in section 4.1, in the present communication and contact between buyers and suppliers currently require a great portion of manual and personal interaction in the majority of sample cases. While some electronic and automated means of communication are already used, humans still play a key role in present buyer-supplier communication and interactions. For instance, the majority of sample companies still use numerous analog, manual and non-automated processes. Nevertheless, these processes increasingly become digitized and automatized (section 4.3), which significantly changes the way communication and data exchange are conducted (Dweekat *et al.*, 2017). However, these attempts for digitization might not unfold as quickly as intended. This applies especially for many SMEs, which are expected to maintain personal relationships (Müller *et al.*, 2018).

Industry 4.0 technologies allow collecting, processing and analyzing data across the value chain (Kagermann *et al.*, 2013). Subsequently, humans' roles change as in the future, they mainly focus on strategic tasks interfering into operative processes only in exceptional cases and during escalations (Kiel *et al.*, 2017). For this reason, personal contact is about to decrease significantly on an operational level in BSRs. On a strategic level, however, personal contact and interaction among humans might maintain its current importance or even increase significantly following concerns about trust in digital technologies. This, in turn, requires a good relationship between companies (Hofmann and Rüsch, 2017). However, personal contact does not get superfluous because decision-making, personal relationships and monitoring activities remain important (Kiel *et al.*, 2017).

The frequency of contact between buyers and suppliers is currently rather high being mainly based on manual and personal contact. This form of contact will drop significantly, as processes will be digitized, automated and interconnected (Hofmann and Rüsch, 2017). Personal contact is however still necessary to determine a strategic framework. With value creation processes circulating within a determined framework, hardly any personal contact is necessary. Nevertheless, especially SMEs will still work with manual and semi-digitized solutions in many cases (Müller *et al.*, 2018). In addition, transparency of processes and data increase, which in turn calls for less personal contact to get relevant data. Given the changes as for automatized and digitized processes, the frequency of data exchange will increase significantly, as real-time data is exchanged across value creation stages in the value chain (Dweekat *et al.*, 2017).

5.4 Digital platforms

As shown in section 4.1, the results reveal that only some companies use platforms within their value creation process so far, but further sample companies state they will use platforms in the future (section 4.3). Platforms facilitate data exchange as various companies use a common technical solution, with interfaces to individual systems (Gottge *et al.*, 2020; Kiel *et al.*, 2017; Osmonbekov and Johnston, 2018). However, creating and implementing platforms requires enormous investments as for infrastructure, software solutions, management of interfaces and cultural changes, just like the digitalization of SCM in general (Schmidt *et al.*, 2019).

5.5 Drivers for BSRs changes in Industry 4.0

Several company-internal drivers and external framework conditions can explain the transformation of BSRs (section 4.2). It is notable that the results indicate external framework conditions are considered to be more important. Customers, competitors and macroeconomic influences like technological changes play a crucial role in transforming BSRs. In contrast, several companies transform their BSRs motivated by the striving for differentiation, profitability and transparency (Ghadge *et al.*, 2020; Legenvre *et al.*, 2020; Tu, 2018).

A strengthened relationship in the context of Industry 4.0 can serve each company manifold (Kagermann *et al.*, 2013). For instance, on an operational level, companies can integrate functions such as purchasing and procurement, logistics and manufacturing. On a strategical level, cooperation can be strengthened, for instance, by undertaking common research and development activities (Villena *et al.*, 2010). Doing so may reduce cost, improve responsiveness, facilitate decision-making and increase efficiency (Dweekat *et al.*, 2017; Kagermann *et al.*, 2013; Tu, 2018; Villena *et al.*, 2010). A stronger relationship enables providing a superior value proposition by aligning the value creation process on the end customers' needs and serve to build up a competitive advantage (Wiengarten *et al.*, 2016). Sharing information may increase productivity and decrease inventory levels, maintenance and manufacturing costs. In order to efficiently exploit advantages of cross-company cooperation, sharing information not only with direct first-tier suppliers, but also with indirect suppliers of the entire upstream value creation process is necessary (Vanpoucke *et al.*, 2017).

In sum, Industry 4.0 provides the potential to transform BSRs creating cross-company value creation networks that serves to increase SC efficiency and overall value creation output (Kiel *et al.*, 2017; Papert and Pflaum, 2017; Tu, 2018; Wu *et al.*, 2016).

6. Conclusion

6.1 Theoretical implications

The study uses qualitative empirical data from 45 interviews with experts from German and Austrian companies to analyze how BSRs are reshaped in the context of Industry 4.0 contributing to extant studies in several ways:

First, extant studies mostly focus on the implications digital technologies have on corporate functions, for example purchasing and logistics and on SCM in general lacking a holistic Industry 4.0 view and disregarding implications on BSRs (e.g. Abdel-Basset *et al.*, 2018; Bienhaus and Haddud, 2018; Calatayud *et al.*, 2018; Legenvre *et al.*, 2020; Vanpoucke *et al.*, 2017). Our study adds value conducting an analysis on how Industry 4.0 holistically affects BSRs from a strategic perspective and in doing so, extends the current state of research in this field.

Second, the paper broadens the current perspective that digital technologies and Industry 4.0 may excessively automatize purchasing, logistics and SCM activities (e.g. Bienhaus and Haddud, 2018; Legenvre *et al.*, 2020). While this might be true for several operational tasks, applying a more nuanced view reveals that, according to the interviewees, personal contact remains necessary in BSRs, for example when building up cross-company trust, especially when cooperating with SMEs (Müller *et al.*, 2018). Additionally, the paper extends the literature by differentiating between types of products and value offers in determining BSR changes in Industry 4.0 contexts (e.g. Wikner and Bäckstrand, 2018).

Third, the paper links recent general transition trends in SCM and in BSRs to transformations caused by Industry 4.0 (e.g. Vanpoucke *et al.*, 2013; Thun, 2010). Among others, the paper finds relationships between buyers and suppliers to become more intense in nature, especially because this is a requirement to manufacture complex digital and interconnected system solutions, as explained by the interviewees. Given vast technological progresses, data-based value offerings and business models that require cross-company interconnections, the trend to integrated downstream value creation processes can be expected to intensify in Industry 4.0 contexts (Dweekat *et al.*, 2017; Manavalan and Jayakrishna, 2019; Tjahjono *et al.*, 2017). Further, interviewees describe that companies continue to consolidate their supplier base, focusing on important strategic suppliers in Industry 4.0 (Dedrick *et al.*, 2008; Wiengarten *et al.*, 2016).

6.2 Managerial implications

The findings provide several implications for management and corporate practice. First, managing BSRs in the context of Industry 4.0 requires a change of management mindset, such as, long-term orientation, holistic integral thinking and cooperation among equals as discussed by the interviewees. Although such developments have been highlighted in the past, the study is among the first to find that Industry 4.0 might even reinforce this development. Second, it will become crucial for organizations to build up knowledge and expertise, for instance, about emerging technologies and technical solutions, such as digital platforms. This calls for acquiring sufficient experts, internally building up knowledge and looking for external knowhow. Third, choosing adequate suppliers will gain further importance according to the interviewees, which requires adequate evaluation criteria and measures. These have to relate to the requirements and developments in the digital era. Further, suppliers have the opportunity to grasp the central aspects of these developments and strategically develop their own capabilities and positioning accordingly. Fourth, it is necessary to conduct organizational and technical changes to work more closely with suppliers and improve BSRs. In this context, processes and communication need to be enhanced, with a focus on establishing common standards and unifying interfaces. Fifth, platforms and platform business models possess various potentials. Managers are therefore encouraged to rethink relationships to suppliers and process transactions accordingly and implement and use platforms within their value creation process. Sixth, numerous interviewees suggest that value chains need to be handled as value creation networks stretching from end to end including the customers. This includes rethinking and reevaluating current, mainly cost-driven approaches in supplier selection and evaluation. Keeping these aspects in mind may assist companies to raise Industry 4.0's full potential as for BSRs, which serve to secure long-term and sustainable competitive advantages.

6.3 Limitations and implications for further research

The study faces some limitations indicating space for further research. First, the study's exploratory and qualitative nature entails restrictions. Even though qualitative studies facilitate analyzing emerging topics, developing theoretical contributions from the empirical data remains rather difficult. To be able to derive adequate theoretical implications, the paper follows a widely accepted and appreciated analysis procedure and consolidated empirical data from individual cases while maintaining relevant informational content. Further, various biases are discussed in the methodology-section, e.g. key informant and retrospective bias, along with measures to reduce their impact and to increase results' reliability. In the future, the study can be complemented by quantitative empirical research to validate the results and quantifying the effects.

As far as the data sample is concerned, some restrictions are worth discussing. The empirical data is exclusively limited to German and Austrian companies of selected industry sectors for the aforementioned reasons. This must be kept in mind when generalizing the results and transferring them to different countries and industry sectors. Future studies could focus on further industry sectors and include service industries to verify the generalizability of our results. Given the differing individual industries' determinants and environments, research could analyze industry-specific differences as for BSRs. In addition, the study solely analyzes BSRs from buyers' perspectives, potentially including single respondent bias. Integrating the supplier perspective, for example interviewing experts from the suppliers' sales and marketing management would complement the study and its findings. Furthermore, future studies could differentiate between BSRs on different value chain stages, e.g. first-tier and second-tier suppliers, to discover and unveil transformation processes and differences in BSRs on a global value chain level. In so doing, special attention should be given to SMEs, as they contribute greatly to the overall value creation. Last but not least, the transformation process calls for special attention and, for this reason, further studies could investigate incentives for supplier integration, integration steps and processes, shared benefits and risks within the value chain and economic output effects.

References

Abdel-Basset, M., Manogaran, G. and Mohamed, M. (2018), "Internet of Things (IoT) and its impact on supply chain: a framework for building smart, secure and efficient systems", *Future Generation Computer Systems*, Vol. 86, pp. 614-628.

Bag, S., Telukdarie, A., Pretorius, J.H.C. and Gupta, S. (2018), "Industry 4.0 and supply chain sustainability: framework and future research directions", *Benchmarking: An International Journal*, Vol. ahead-of-print No. ahead-of-print.

Barreto, L., Amaral, A. and Pereira, T. (2017), "Industry 4.0 implications in logistics: an overview", *Procedia Manufacturing*, Vol. 13, pp. 1245-1252.

Ben-Daya, M., Hassini, E. and Bahroun, Z. (2019), "Internet of things and supply chain management: a literature review", *International Journal of Production Research*, Vol. 57 Nos 15/16, pp. 1-24.

Bienhaus, F. and Haddud, A. (2018), "Procurement 4.0: factors influencing the digitization of procurement and supply chains", *Business Process Management Journal*, Vol. 24 No. 4, pp. 965-984.

Büyüközkan, G. and Göçer, F. (2018), "Digital supply chain: literature review and a proposed framework for future research", *Computers in Industry*, Vol. 97, pp. 157-177.

Calatayud, A., Mangan, J. and Christopher, M. (2018), "The self-thinking supply chain", *Supply Chain Management: An International Journal*, Vol. 115 No. 6, pp. 22-37.

Dedrick, J., Xu, S.X. and Zhu, K.X. (2008), "How does information technology shape supply-chain structure? Evidence on the number of suppliers", *Journal of Management Information Systems*, Vol. 25 No. 2, pp. 41-72.

Dweekat, A.J., Hwang, G. and Park, J. (2017), "A supply chain performance measurement approach using the internet of things: toward more practical SCPMS", *Industrial Management and Data Systems*, Vol. 117 No. 2, pp. 267-286.

Edmondson, A.C. and McManus, S.E. (2007), "Methodological fit in management field research", *Academy of Management Review*, Vol. 32 No. 4, pp. 1246-1264.

Eisenhardt, K.M. and Graebner, M.E. (2007), "Theory building from cases: opportunities and challenges", *Academy of Management Journal*, Vol. 50 No. 1, pp. 25-32.

Ghadge, A., Kara, M.E., Moradlou, H. and Goswami, M. (2020), "The impact of Industry 4.0 implementation on supply chains", *Journal of Manufacturing Technology Management*, Vol. 31 No. 4, pp. 669-686.

Gioia, D.A., Corley, K.G. and Hamilton, A.L. (2013), "Seeking qualitative rigor in inductive research: notes on the Gioia methodology", *Organizational Research Methods*, Vol. 16 No. 1, pp. 15-31.

Gottge, S., Menzel, T. and Forslund, H. (2020), "Industry 4.0 technologies in the purchasing process", *Industrial Management and Data Systems*, Vol. 120 No. 4, pp. 730-748.

Haddud, A., DeSouza, A., Khare, A. and Lee, H. (2017), "Examining potential benefits and challenges associated with the Internet of Things integration in supply chains", *Journal of Manufacturing Technology Management*, Vol. 28 No. 8, pp. 1055-1085.

Hofmann, E. and Rüsch, M. (2017), "Industry 4.0 and the current status as well as future prospects on logistics", *Computers in Industry*, Vol. 89, pp. 23-34.

Holsti, O.R. (1969), *Content Analysis for the Social Sciences and Humanities*, Addison-Wesley, Reading, MA.

Kagermann, H., Wahlster, W. and Helbig, J. (2013), *Recommendations for Implementing the Strategic Initiative Industrie 4.0 – Final Report of the Industrie 4.0 Working Group*, Industry-Science Research Alliance, Frankfurt am Main.

Kiel, D., Müller, J.M., Arnold, C. and Voigt, K.I. (2017), "Sustainable industrial value creation: benefits and challenges of Industry 4.0", *International Journal of Innovation Management*, Vol. 21 No. 8, pp. 1740015-1-1740015-34.

Krippendorff, K. (2013), *Content Analysis*, Sage, Los Angeles, CA.

Lee, H.L., Padmanabhan, V. and Whang, S. (2004), "Information distortion in a supply chain: the bullwhip effect", *Management Science*, Vol. 50 No. 12, pp. 1875-1886.

Legenvre, H., Henke, M. and Ruile, H. (2020), "Making sense of the impact of the internet of things on purchasing and supply management: a tension perspective", *Journal of Purchasing and Supply Management*, Vol. 26 No. 1, p. 100596.

Manavalan, E. and Jayakrishna, K. (2019), "A review of Internet of Things (IoT) embedded sustainable supply chain for industry 4.0 requirements", *Computers and Industrial Engineering*, Vol. 127, pp. 925-953.

Miles, M.B. and Huberman, M.A. (1994), *Qualitative Data Analysis*, Sage, Thousand Oaks, CA.

Müller, J.M. (2019), "Business model innovation in small-and medium-sized enterprises: strategies for industry 4.0 providers and users", *Journal of Manufacturing Technology Management*, Vol. 30 No. 8, pp. 1127-1142.

Müller, J.M., Buliga, O. and Voigt, K.-I. (2018), "Fortune favors the prepared: how SMEs approach business model innovations in industry 4.0", *Technological Forecasting and Social Change*, Vol. 132, pp. 2-17.

Müller, J.M., Buliga, O. and Voigt, K.-I. (2020), "The role of absorptive capacity and innovation strategy in the design of Industry 4.0 business models - a comparison between SMEs and large enterprises", *European Management Journal*, Vol. ahead-of-print No. ahead-of-print.

Obal, M. and Lancioni, R.A. (2013), "Maximizing buyer–supplier relationships in the digital era: concept and research agenda", *Industrial Marketing Management*, Vol. 42 No. 6, pp. 851-854.

Olhager, J. (2003), "Strategic positioning of the order penetration point", *International Journal of Production Economics*, Vol. 85 No. 3, pp. 319-329.

Osmonbekov, T. and Johnston, W.J. (2018), "Adoption of the internet of things technologies in business procurement: impact on organizational buying behavior", *Journal of Business and Industrial Marketing*, Vol. 33 No. 6, pp. 781-791.

Papert, M. and Pflaum, A. (2017), "Development of an ecosystem model for the realization of internet of things (IoT) services in supply chain management", *Electronic Markets*, Vol. 27 No. 2, pp. 175-189.

Porter, M.E. and Heppelmann, J.E. (2014), "How smart connected products are transforming competition", *Harvard Business Review*, Vol. 92, pp. 64-88.

Schmidt, M.-C., Veile, J.W., Müller, J.M. and Voigt, K.-I. (2019), "Kick-start for connectivity - how to implement digital platforms successfully in industry 4.0", *Technology Innovation Management Review*, Vol. 9 No. 10, pp. 5-15.

Thun, J.H. (2010), "Angles of integration: an empirical analysis of the alignment of internet-based information technology and global supply chain integration", *Journal of Supply Chain Management*, Vol. 46 No. 2, pp. 30-44.

Tjahjono, B., Esplugues, C., Ares, E. and Pelaez, G. (2017), "What does industry 4.0 mean to supply chain?", *Procedia Manufacturing*, Vol. 13, pp. 1175-1182.

Tu, M. (2018), "An exploratory study of Internet of Things (IoT) adoption intention in logistics and supply chain management: a mixed research approach", *The International Journal of Logistics Management*, Vol. 29 No. 1, pp. 131-151.

Vanpoucke, E., Vereecke, A. and Boyer, K.K. (2013), "Triggers and patterns of integration initiatives in successful buyer–supplier relationships", *Journal of Operations Management*, Vol. 32, pp. 15-33.

Vanpoucke, E., Vereecke, A. and Muylle, S. (2017), "Leveraging the impact of supply chain integration through information technology", *International Journal of Operations and Production Management*, Vol. 37 No. 4, pp. 510-530.

Veile, J.W., Kiel, D., Müller, J.M. and Voigt, K.-I. (2019), "Lessons learned from Industry 4.0 implementation in the German manufacturing industry", *Journal of Manufacturing Technology Management*, Vol. ahead-of-print No. ahead-of-print.

Villena, V.H., Revilla, E. and Choi, T.Y. (2010), "The dark side of buyer–supplier relationships: a social capital perspective", *Journal of Operations Management*, Vol. 29 No. 6, pp. 561-576.

Wiengarten, F., Humphreys, P., Gimenez, C. and McIvor, R. (2016), "Risk, risk management practices, and the success of supply chain integration", *International Journal of Production Economics*, Vol. 171 No. 3, pp. 361-370.

Wikner, J. and Bäckstrand, J. (2018), "Triadic perspective on customization and supplier inter-action in customer-driven manufacturing", *Production and Manufacturing Research*, Vol. 6 No. 1, pp. 3-25.

Wu, L., Yue, X., Jin, A. and Yen, D.C. (2016), "Smart supply chain management: a review and implications for future research", *The International Journal of Logistics Management*, Vol. 27 No. 2, pp. 395-417.

Appendix 1

Table A1. Sample overview

Interview No.	Management position	Company tenure [years]	Industry tenure [years]	Industry sector	Number of employees [2017]	Sales volume [in million EUR; 2017]	Interview duration [Min:Sec]
1	Lower	5	5	Automotive	(50,000–150,000]	>50,000	24:47
2	Lower	6	6	Automotive	(50,000–150,000]	>50,000	36:00
3	Lower	1	4	Automotive	>150,000	>50,000	54:36
4	Lower	20	20	Automotive	(50,000–150,000]	>50,000	60:42
5	Middle	3	9	Automotive	(50,000–150,000]	>50,000	53:03
6	Top	1	1	Automotive	(1,000–5,000]	(1,000–1,500]	34:04
7	Middle	13	13	Automotive suppliers	>150,000	>50,000	61:37
8	Middle	6	6	Automotive suppliers	>150,000	>50,000	41:24
9	Middle	10	10	Automotive suppliers	>150,000	>50,000	43:24
10	Middle	6	19	Automotive suppliers	>150,000	(10,000–50,000]	50:30
11	Middle	19	19	Automotive suppliers	>150,000	(10,000–50,000]	70:28
12	Lower	2	2	Automotive suppliers	(50,000–150,000]	(10,000–50,000]	63:04
13	Lower	1	1	Automotive suppliers	(50,000–150,000]	(10,000–50,000]	63:26
14	Lower	1	7	Automotive suppliers	(50,000–150,000]	(10,000–50,000]	66:18
15	Middle	25	25	Automotive suppliers	(10,000–50,000]	(5,000–10,000]	56:32
16	Top	2	2	Automotive suppliers	(5,000–10,000]	(500–1,000]	22:44
17	Top	4	4	Automotive suppliers	(1,000–5,000]	(500–1,000]	55:41
18	Top	9	14	Automotive suppliers	(1,000–5,000]	(250–500]	43:05
19	Lower	2	2	Consumer goods	(50,000–150,000]	(10,000–50,000]	24:30
20	Middle	2	2	Consumer goods	(5,000–10,000]	(1,000–1,500]	30:05
21	Top	23	23	Consumer goods	(1,000–5,000]	(500–1,000]	55:38
22	Middle	10	16	Consumer goods	(1,000–5,000]	(250–500]	45:19
23	Lower	11	11	Electronic and electrical engineering	>150,000	>50,000	51:45
24	Lower	2	2	Electronic and electrical engineering	>150,000	>50,000	62:45
25	Middle	9	9	Electronic and electrical engineering	(50,000–150,000]	(5,000–10,000]	61:58
26	Top	6	6	Electronic and electrical engineering	(10,000–50,000]	(5,000–10,000]	60:35
27	Top	9	9	Electronic and electrical engineering	(10,000–50,000]	(5,000–10,000]	43:41
28	Top	9	9	Electronic and electrical engineering	(10,000–50,000]	(1,500–5,000]	49:42
29	Middle	9	9	Electronic and electrical engineering	(10,000–50,000]	(1,500–5,000]	61:31
30	Top	7	7	Electronic and electrical engineering	(1,000–5,000]	(1,500–5,000]	60:08

(continued)

Table A1.

Interview No.	Management position	Company tenure [years]	Industry tenure [years]	Industry sector	Number of employees [2017]	Sales volume [in million EUR; 2017]	Interview duration [Min:Sec]
31	Lower	1	1	Electronic and electrical engineering	(1,000–5,000]	(0–250]	58:40
32	Middle	7	7	Mechanical engineering	(50,000–150,000]	(10,000–50,000]	40:53
33	Middle	1	1	Mechanical engineering	(10,000–50,000]	(1,500–5,000]	59:36
34	Middle	12	29	Mechanical engineering	(5,000–10,000]	(1,000–1,500]	86:59
35	Top	11	11	Mechanical engineering	(5,000–10,000]	(1,000–1,500]	73:00
36	Top	5	22	Mechanical engineering	(1,000–5,000]	(500–1,000]	99:45
37	Lower	4	4	Mechanical engineering	(1,000–5,000]	(250–500]	51:31
38	Top	2	2	Mechanical engineering	(0–1,000]	(250–500]	61:41
39	Top	39	39	Mechanical engineering	(0–1,000]	(0–250]	76:17
40	Middle	26	26	Mechanical engineering	(0–1,000]	(0–250]	78:45
41	Top	3	3	Mechanical engineering	(0–1,000]	(0–250]	60:30
42	Top	2	2	Mechanical engineering	(0–1,000]	(0–250]	61:52
43	Top	13	13	Raw materials processing	>150,000	(10,000–50,000]	53:03
44	Top	22	22	Raw materials processing	(5,000–10,000]	(1,500–5,000]	44:31
45	Top	8	8	Raw materials processing	(10,000–50,000]	(1,500–5,000]	56:57

Appendix 2. Interview guideline

Part 1: Questions about the expert and the corporate context

(1) What is your current position and function in the company?

(2) Could you please briefly describe your career?

(3) What do you understand by "Industry 4.0"?

(4) To what extent do you currently integrate suppliers into considerations and projects in the context of Industry 4.0?

(5) Is your company a user or provider of Industry 4.0-solutions?

Part 2: Current relationship with suppliers

(1) Could you please explain the current relationship to your suppliers? In particular, elaborate on (a) the relationship of trust, (b) the nature of contact and (c) the frequency of contact.

Part 3: Future relationship with suppliers

(1) In which areas do you want to work more closely with suppliers in the future? In which less?

(2) How do you expect your BSR to be in the medium and long term, i.e. in 5–10 years? In particular, please explain the differences in comparison to the present.

(3) What role does Industry 4.0 play in the transformation?

(4) What are drivers and causes of future changes in BSRs?

Part 4: Conclusion

(1) Do you have any comments, further information or questions?

Appendix 3

Theme	Aggregate dimensions[a]	Second-order themes[a]	First-order (informant) concepts
Present buyer-supplier relationships	Relationship of trust (42)	Positive, close relationship of trust (34)	Common philosophy; trustful, close and partner-like; long-term relationships; (end) customer focus; joint planning and research and development activities
		Low, rather negative relationship of trust (21)	Price-, cost- and volume-driven; efficiency-focus; distrust; control efforts; short-term relationships; multi-sourcing
	Way of communication and contact (40)	Manual and personal contact (40)	Analog, manual and non-automated processes: media (telephone, e-mail, conference calls, telefax, face-to-face, events, meetings); reasons (high topic relevance, missing technical equipment); topics (contract negotiations, special topics, deviations)
		Electronic and automated communication (23)	Automatized, digitalized data transmission, processes and communication; supplier connection and integration; interconnectedness
		Platforms (8)	Using platforms; platform-based interconnectedness; exchange of information, products, services
	Frequency of communication (28)	High contact frequency (23)	Daily, weekly, or monthly contact; continuous contact; regular contact
		Low contact frequency (14)	Quarterly, half-yearly, or annual contact; contact upon need; contact in case of changing framework conditions
	Framework conditions (27)	Type of supplier (22)	Individual suppliers and supplier groups; supplier relevance
		Product-dependent/ volume-dependent (8)	Sales volume-related; product-dependent (standard goods vs. strategic goods); product volume-dependent
Drivers and causes for the transformation	Market dynamics (30)	Customers (24)	Customer needs and requirements (individuality, quality, transparency, flexibility, reliability, speed, costs, certifications)
		Competition (9)	Competition; aggressive competitors; new market entrants; difficult differentiation
		Market (6)	Market; market dynamics; market changes; new markets
	Macroeconomic influences (27)	Technology (19)	Technology-driven; innovation pressure; digitalization; data analysis; decreasing costs for technologies
		Regulatory influences and compliance (8)	Legal regulations; regulatory requirements; parts traceability; statutory disclosure duty; environmental regulations; information transparency
		External trends (6)	Shortage of specialists; complexity of value chains; mega trends

Table A2.
Empirical data structure

(*continued*)

Theme	Aggregate dimensions[a]	Second-order themes[a]	First-order (informant) concepts
	Differentiation (26)	Speed (9)	Delivery times; reaction times; time-to-market; lead times
		Value proposition (5)	Solutions; products; services; product lifecycle; extending product portfolio
		Innovative capability (5)	Supplier innovations; development cooperations; innovations
		Flexibility and reliability (6)	Flexibility; response capacity; delivery reliability; process reliability
		Business models (2)	New business models; adaptions of existing business models
	Profitability and ability to compete (23)	Cost reduction (15)	Cost reductions (personnel, complexity, coordination); expense factor; cost efficiency
		Optimization (12)	Efficiency enhancement; coordination efforts and needs; resource allocation
	Transparency (9)	Information (7)	Transparency (fault deliveries, storage capacity); performance controlling; information needs
		Risks (2)	Risk prevention; risk management
Future buyer-supplier relationships	Digitized, automatized processes (33)	Digitization and automatization of processes (18)	Digitized, automated operative processes (sourcing, negotiating, purchasing, ordering); platform-based processes; systems control routine processes
		Data exchange (9)	Direct and automated data exchange; real-time data
		Personal contact (9)	Exceptional cases and escalations; reduction of contact frequency; less manual efforts
		Transparency (7)	Transparent demand forecasts and requirements planning; transparent order processing; process transparency
		Strategical framework conditions (4)	Strategic orientation (framework, contracts); long-term, strategic relationships
		Deviation management (2)	Intervention only for exceptions; deviation management
		Role of artificial intelligence (1)	Decision making by artificial intelligence
	Platforms (16)	Using platform (7)	Using platforms; platform-based processes; interconnection of stand-alone solutions; cooperation via platforms
		Process automatization and digitization (7)	Platform-based, automatized operative processes; automatized tender processes and offer duties
		Data exchange and transparency (5)	Transparency (forecasts, production planning, stocks, capabilities, needs); parts and supplier traceability
	More intense relationships (16)	Improved bonds of trust and enhanced relationship (8)	Relationship of trust; intensive relationships; closer and open forms of cooperation; cooperations among equals; long-term orientation
		Cooperative partnerships and cooperations (10)	Partnerships and cooperations (Industry 4.0-implementation support, joint problem solving, feasibility studies)

(*continued*)

Table A2.

Theme	Aggregate dimensions[a]	Second-order themes[a]	First-order (informant) concepts
	Integration of suppliers (12)	System and process integration (7)	Process integration; IT-systems integration; cross-company project teams
		Integration in research and development activities (5)	Increased and early supplier integration in development processes
	Supplier base consolidation (11)	Concentration on strategical suppliers (8)	Growing importance of strategic system suppliers; focus on few strategic suppliers
		Reduction of supplier quantity (6)	Supplier base consolidation; smaller supplier base; concentration tendencies (technological requirements, efforts, willingness)
	Role of humans (8)	Personal and manual contact still important (7)	Personal contact important; regular meetings; relevance of personal relationships
		Decision-making (2)	Supplier prioritization; human prioritization; decision-making
		Monitoring (2)	Human intervention in case of errors; monitoring of automated, operational processes
		Strategical tasks (2)	Focus on strategical tasks; strategy
		Less operative, administrative tasks (2)	Decreasing manual activities and processes; less administrative tasks

Table A2.

Note(s): [a]Frequency of mentions indicated in brackets; multiple responses allowed

Corresponding author
Johannes Wolfgang Veile can be contacted at: johannes.veile@fau.de