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# Supplier Integration in Industry 4.0 – Requirements and Strategies

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*Cross-company networking is essential to successfully implement Industry 4.0. In this context, numerous new demands on suppliers arise leading to integration challenges that require specific integration strategies. While these topics are important in business practice, an aggregated holistic overview is still missing. Therefore, this article examines new demands on suppliers, challenges in the implementation process, and integration strategies for supplier integration in the context of Industry 4.0. Expert interviews with 15 different industrial companies from the sectors mechanical and plant engineering, electronics and electrical engineering, automotive, and information and communication technology serve as an empirical basis. This study provides insights into the challenges and strategies of supplier integration, helps academia to understand this topic, and indicates need for future research. Furthermore, this paper develops implications for corporate practice in the area of supplier management.*

**Keywords:** Industry 4.0; Industrial Internet of Things; Supplier Integration; Integration Strategies

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# 1 Introduction

Industry 4.0 aims to establish intelligent, self-managing, and interconnected industrial value creation to ensure future competitiveness of the manufacturing industry (Kagermann et al., 2013; Kang et al., 2016; Lasi et al., 2014). Both research and practice have mainly focused on technological developments and the technical implications for value creation so far (Brettel et al., 2014; Emmrich et al., 2015; Kagermann et al., 2013; Kans & Ingwald, 2016; Kowalkowski et al., 2013; Liao et al., 2017; Rennung et al., 2016). Furthermore, almost exclusively large companies have been the focus of academia and corporate practice (Kowalkowsi et al., 2013; Radziwon et al., 2014).

Up to the present day, Industry 4.0 is primarily thought within the boundaries of a company and consequently present efforts aim at implementing the concept in a company. Yet, the predicted potential of intelligent interconnected value-added processes can only be exploited in its entirety by interconnecting companies and value chains resulting in networks (Kagermann et al., 2013; Lasi et al., 2014). Therefore, the implementation of the holistic concept Industry 4.0 also requires a holistic approach.

However, integration processes across company boundaries pose numerous challenges. First, such integration requires openness, willingness to cooperate, and compatible technologies on all sides (Kiel et al., 2017; Müller et al., 2018a). Second, the integration of suppliers requires, e.g., them to have the necessary infrastructure and drive forward the implementation of Industry 4.0. As suppliers are often small and medium-sized enterprises (SMEs), some might have neither the necessary resources nor access to the required knowledge (Icks et al., 2017, Müller et al., 2018b). Therefore, especially SMEs need to find adequate partners for cooperation (Müller et al., 2017).

The aim of this study is to analyze how to integrate suppliers in the context of Industry 4.0. The following research questions are proposed:

*(1) Which requirements need to be met when integrating suppliers?*

*(2) Which challenges arise when integrating suppliers?*

*(3) Which strategies can be used to integrate suppliers?*

Shedding light into the research object is important for several reasons. The way suppliers are integrated into the value creation process of a company has an impact on the extent to which possibilities Industry 4.0 can be used at all (Siepmann, 2016).

Supplier integration represents a source of differentiation and can therefore help to create sustainable competitive advantages. Last but not least, versatile, real-time-optimized, and autonomous cross-company value creation networks can only be established through adequate supplier integration, which is the overriding goal of Industry 4.0 (Bauernhansl, 2014).

# 2 Theoretical background

## 2.1 Industry 4.0

The term ”Industry 4.0” refers to a paradigm shift in industrial value creation. It is particularly widespread in the German-speaking world (Burmeister et al., 2015; Lasi et al., 2014), while the term ”Industrial Internet of Things” is particularly used in the Anglophonic world (Hartmann & Halecker, 2015; IIC, 2017). The origin of Industry 4.0 dates back to the year 2011 and was significantly influenced by the work of Kagermann et al. (2011) in the context of the Hanover Fair. Furthermore, they published implementation recommendations in 2013 in a final report of the Working Group Industry 4.0 (Kagermann et al., 2013).

In the age of industrialization, technical innovations repeatedly led to paradigm shifts that are called ”industrial revolutions” ex-post (Lasi et al., 2014). The first industrial revolution began at the end of the 18th century and was characterized by the mechanization of the value creation process and the use of water and steam power. Dated back to the beginning of the 20th century, the second industrial revolution was characterized by mass production through assembly line production, the application of the Taylor principle of division of labor, and the use of electrical energy. The use of electronics and information technology to automate and digitize production heralded the third industrial revolution in the 1970s. All industrial revolutions have led to an increasing degree of complexity of the production systems (Bauernhansl, 2014; Kagermann et al., 2013; Kelkar et al., 2014; Lasi et al., 2014).

It is predicted that the present economy is at the beginning of a fourth industrial revolution, summarized by the term Industry 4.0. This new paradigm shift is characterized by a digital interconnection and virtualization of the industrial value creation process (Bauernhansl, 2014; Kagermann et al., 2013; Kelkar et al., 2014; Lasi et al., 2014). For the first time in history, a change of paradigm is announced a priori (Drath & Horch, 2014). For this reason, Industry 4.0 is to be understood as a vision whose potential can be realized in the future (Drath & Horch, 2014, Lasi et al., 2014). However, as the technical foundations have existed for some time, while the practical implementation is only gradually developing, some scientists perceive Industry 4.0 more as an evolution than a revolution (Kagermann, 2014; Sendler, 2013).

Industry 4.0 is controversially discussed in science, hence no common understanding has emerged so far (Bauer et al., 2014). According to Bauer et al. (2014, p. 18), Industry 4.0 is a ”real-time capable, intelligent, horizontal, and vertical networking of people, machines, objects” and information and communication technology systems. Based on intelligent, digitally interconnected systems, people, machines, plants, logistic processes, and products can communicate and cooperate in real-time with each other (Platform Industrie 4.0, 2017). Industry 4.0 is ”a new level of organization and control of the entire value chain across the life cycle of products” (Platform Industry 4.0, 2017). The interconnection of the operational value creation process takes place across corporate functions, companies, and entire value creation chains (Kagermann et al., 2013). Therefore, a high level of standardization of interfaces between companies is required (Müller & Voigt, 2017).

Using new technologies enables the development of an intelligent value-added system within the framework of Industry 4.0. First, cyber-physical systems (CPS) result from the interconnection of embedded systems and link information technologies with mechanical and electrical components (Becker, 2015; Kagermann et al., 2013; Zhou et al., 2015). In addition, the collection, analysis, and use of large amounts of data play a decisive role and is subsumed among the term ”big data”. Finally, cloud solutions for storing and transmitting data via stable networks are used (Rüßmann et al., 2015; Bauer et al., 2014).

Research on the subject of Industry 4.0 is generally still in its infancy, which is particular true for the implementation across company borders and value creation chains.

## 2.2 Supplier Management and supplier integration

Supplier management is ”the design, management, and development of a company’s supplier portfolio and supplier relationships” (Wagner, 2002, p. 11). The aim of supplier management is to secure a company’s demand through an efficient supplier network and thereby contribute to the value creation (Helmold & Terry, 2016).

Supplier integration is a sub-process of supplier management (Helmold & Terry, 2016) representing a form of vertical cooperation (Möller, 2002). This implies close strategic cooperation with both key suppliers and customers in order to generate advantages (Schoenherr & Swink, 2012; Thun, 2010; Wiengarten et al., 2016). The goal of supplier integration is to design integration strategies, practices, processes, and behaviors in a collaborative, synchronized, and well-controllable manner (Zhao et al., 2015). Combining a company’s resources with the capabilities of its supplier and realizing joint activities can help to generate sustainable competitive advantages (Rink & Wagner, 2007). Shortening product development and product life cycles and the associated fast, flexible, and efficient production processes in the context of Industry 4.0 increases the importance of supplier integration (Hofbauer et al., 2016).

# 3 Methodology

## 3.1 Research design

The study follows a qualitative research design to answer the research questions (Gläser & Laudel, 2010). A qualitative design is characterized by considering and analyzing different perspectives and integrating the interviewees’ and researchers’ views (Flick, 1995). This design is particularly suitable for the research at hand because supplier integration in the context of Industry 4.0 is a very topical issue and little comprehensive knowledge is available (Kaiser, 2014).

Semi-standardized in-depth expert interviews serve as a data basis (Gläser & Laudel, 2010). All interviews followed an interview guideline and were conducted via telephone in German. On the one hand, the interview guideline was designed so that the interviewee was able to openly respond to questions and present his or her subjective perspective. The result was a natural course of conversation

in which the interviewee could answer freely. In addition, the interviewer could follow up on certain questions or adapt his questions. On the other hand, a partial standardization of the interviews allowed to compare and evaluate the interviews (Mayring, 2015; Gläser & Laudel, 2010). After general questions, the experts were asked about their opinion on the topic of supplier integration in the context of Industry 4.0. The main part contained specific questions on the sub-topics (1) challenges with suppliers in the context of Industry 4.0, (2) expectations of suppliers as for Industry 4.0, (3) and adequate integration strategies. All interviews were audio-recorded and subsequently transcribed with the permission of the interview partners leading to more than 200 pages of text material. For confidentiality reasons, all interviews were anonymized.

## 3.2 Data sample

The data sample comprises 15 semi-standardized in-depth expert interviews. Originally, 46 companies were surveyed, and thereof experts from 15 companies were recruited for an interview, corresponding to a response rate of approximately 33 percent.

The surveyed experts come from a heterogeneous sample of companies, headquartered in the Federal Republic of Germany. The sample includes companies from the sectors electrical engineering and electronics, mechanical and plant engineering, automotive, and information and communication technology. These sectors were chosen because they are representative for the most important sectors in Germany, and as they are in particular, driving forward Industry 4.0 (Kagermann et al., 2013). The following figure shows the distribution of enterprises within the sample.

The size of the sample companies is heterogeneous. It varies in terms of turnover from approximately 150 million to approximately 80 billion euros and in terms of employees from approximately 3,000 to approximately 400,000 employees. All experts hold a position in either medium or upper management and have several years of business experience. The interviewed positions include nine representatives from purchasing departments, of which six are head of purchasing, two Chief Digital Officers, one Chief Executive Officer, one Chief Technology Officer, one head of external cooperation, and one head of supplier management.

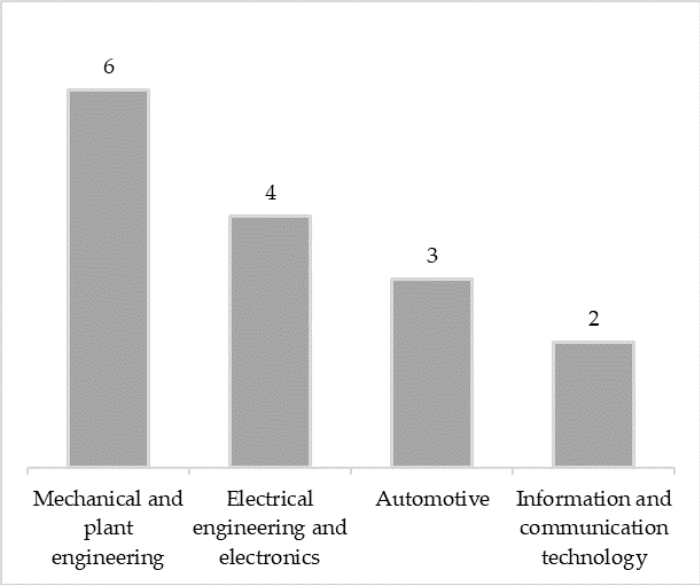


Figure 1: Sector distribution of sample companies

All interviews were conducted from April to June 2017 via telephone. In accordance with the interviewees, the interviews were audio-recorded and transcribed.

## 3.3 Data analysis

The interviews were examined using a qualitative content analysis according to Mayring (2015). Therein, the experts' statements are reduced to their core statements and, later on, paraphrased and subsequently generalized (Mayring, 2015). The paraphrases, which contain similar content, can be divided into few statements, which Mayring calls categories. The categories are formed inductively

using a keyword analysis (Gläser & Laudel, 2010; Kaiser, 2014). The frequency analysis of individual nominations allows an interpretation and analysis of expert statements from which relevant research results can be extracted (Bogner et al., 2014; Gläser & Laudel, 2010; Mayring, 2015).

# 4 Analysis and results

## 4.1 New requirements for suppliers

The increasingly demanded ability to collect, store, and profitably evaluate data is mentioned by ten respondents to be new requirements for suppliers in the context of Industry 4.0. At the same time, the company representatives emphasize that many suppliers have paid little attention to this so far. Therefore, suppliers are demanded expand these abilities by the interviewees, even if those are just supplying parts or raw materials.

Eight respondents considered the creation of interfaces and the implementation of standards to be important requirements. Smooth interfaces are required especially for digital real-time data exchange, as mentioned by the respondents. From their perspective, suppliers need to be willing to adapt to customer-specific standards and interfaces, even if different standards exist among their customers.

The willingness to provide data as a requirement for their own suppliers in the context of Industry 4.0 was mentioned by six respondents. So far, data have often been published only if necessary and hesitantly, which should be done proactively in the future, according to the interviewed experts.

Five respondents named a cultural shift towards common, collaborative value creation within the Industry 4.0 concept as important. In the future, suppliers should no longer respect their own company boundaries as borders, but they should think and act beyond these borders, increasing partnership-based exchange. According to the interviewees, partnership and cooperation needs to be extended, replacing predominant competitive thinking.

The understanding of the shortening innovation cycles by Industry 4.0 to be an essential requirement was named by four respondents. Traditional industrial sectors, such as mechanical engineering, would have to rethink their way of creating value, in order to approach short innovation cycles like those of, e.g., the

software industry. The interviewees regard this as an essential prerequisite in order to, e.g., produce cyber-physical systems or offer platform-based business models.

Three respondents described an increased orientation towards the common end customer of different supply chain partners. Consequently, the primary goal of value creation should focus on the common end customer and his needs, following the opinion of the interviewed experts.

## 4.2 Challenges of supplier integration

Nine surveyed company representatives named a high degree of complexity in supplier integration in the context of Industry 4.0. Inhomogeneous standards and differing requirements across industries hinder the implementation of Industry 4.0 across value chains. For example, different Enterprise-Resource-Planning systems must be harmonized in order to enable a global network.

The lack of resources on the part of suppliers as a hindrance was mentioned by eight respondents. These statements do not only refer to a lack of financial resources, but also to a lack of knowledge and work force.

Another eight respondents stated inadequate structures and interfaces as a challenge. In many companies, different departments work with different standards and a company-wide coordination does not take place.

The suppliers' uncertainty about the expected developments was described by five interviewees. Many suppliers do have a wait-and-see-attitude and, as for now, do not address the issue of Industry 4.0 proactively. This leads to a lack of competence creation instead of using time to gather information and define strategies for Industry 4.0.

Five respondents cited a lack of understanding, particularly as for the urgency of implementing Industry 4.0. This is especially true for SMEs. Instead, sectors would pursue the typical goals, e.g., mechanical engineering strives rather for improving mechanical quality, than preparing for future topics.

Another five respondents described issues of data security and data protection. Until now, issues of data security are not completely clarified from a legal perspective and the question of data ownership remains unclear. Further, concerns such

as hacker attacks and espionage should be taken care of and secure encryption methods should be applied.

Challenges resulting from a changing balance of power were mentioned by five respondents. Suppliers would be afraid of losing importance in the future, as their competence is no longer of central importance in Industry 4.0. In addition, customers are concerned because suppliers could put more pressure on them and even completely bypass or replace them.

Four respondents described possible disruptions because of new competitors as a challenge. There are concerns in particular with regard to platform providers or data-based business models. These could create the core benefit for the customer in the future and thus degrade existing companies as suppliers or completely displace their business model.

A lack of willingness to exchange data on the part of suppliers to be an obstacle was also mentioned by four respondents. For example, there is a lack of understanding that data can only generate value in the future if it is exchanged across the entire value chain. At present, data is considered to be a trade secret and most firms disclose it whenever possible. However, a compromise must be found in order to create advantages for all partners within a value chain.

## 4.3 Integration strategies

Eight respondents described precise and comprehensive communication of common standards as an appropriate approach to supplier integration in Industry 4.0. Many suppliers did not know, which standards were required and which type of cooperation asks for which specific standard. It is therefore essential to clarify issues of standards and to make it easy for the suppliers to understand the requirements.

The establishment of digital platforms as a strategy for integrating suppliers is also mentioned by eight experts. The platforms could be used in different contexts, for example, in procurement, supply chain management, joint tool management, and product development. It is important to increase potentials through joint networking and to make them accessible to all partners in the value chain.

Six of the company representatives cited transparency in communication with suppliers as an essential approach. Thus, honesty and transparency are central

points here. A clear presentation of the consequences following from a lack of cooperation and an honest communication are indispensable in order to cooperate with suppliers in the context of Industry 4.0.

Further, contractual security is an important issue described by two respondents. Suppliers need to have a reliable basis with a long-term perspective in order to be able to make the corresponding investments for the integration process. Since suppliers have to meet different standards for their numerous customers, they aim for keeping their customers for a long period of time, as otherwise specific investments would not payoff. Establishing long-term relationships is the only way to encourage the supplier's willingness to invest in Industry 4.0 and the integration process.

The creation joint business models was mentioned by two respondents. As suppliers can play a key role in new, joint business models in the context of Industry 4.0, this is a way to motivate the suppliers. For example, there are data-driven business models in which the supplier is responsible for data evaluation and is thereby offered an incentive to make investments.

Two of the respondents also mentioned common research and development activities. For example, joint development of Industry 4.0 components and software could help to qualify suppliers for Industry 4.0. It is in the hands of customers to help their suppliers to implement Industry 4.0 and to accelerate their efforts through corresponding demand.

The provision of resources was mentioned by a single respondent. Nevertheless, this integration strategy represents an interesting approach to support suppliers. For instance, specialists can be lent out for consultation and technical components can be made available at low cost or free of charge to speed up the implementation process.

# 5 Conclusion

This article presents the results of 15 in-depth expert interviews as for supplier requirements, challenges during the implementation process, and the adequate integration strategies for supplier integration in the context of Industry 4.0.

According to this study's results, key requirements include developing the ability to collect, store, and evaluate data, creating smooth interfaces, implementing

standards, and creating a willingness to exchange data. In the course of the supplier integration, various challenges arise. The most important ones comprise coping with the high complexity, lacking in resource base, and having no adequate structures and interfaces. The new demands on suppliers and the challenges that arise in supplier integration can be classified into different fields of action that require specific integration strategies for companies.

In the future, important strategical issues are, among others, undertaking a comprehensive communication, establishing common standards, and maintaining long-term contractual security. These provide the basis for establishing strategies to face the challenges. Key strategies include creating digital platforms, carrying our joint business models, and undertaking common research and development activities.

It should be noted that the integration strategies presented by the interview partners reflect the status quo and include the strategic environment of the companies, which represents a limitation of the study at hand. Therefore, companies should review their own strategic options and their individual strategic environment to develop their own supplier integration strategies.

The study aggregates key information that is relevant to practice, as companies can use it as a starting point to develop successful supplier integration strategies in the context of Industry 4.0. Research can also use the results to develop the theoretical basis for future changes in supplier management caused by Industry 4.0.

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