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In-depth Analysis of the Effects of Smart Services on Value Creation

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Abstract: The manufacturing industry is currently undergoing a tremendous change in value creation caused by two megatrends: digitalization and servitization. In response to these two trends, new hybrid market offerings are emerging, so-called Smart Services. Traditional manufacturing companies planning to provide these data-based Services are confronted with new requirements of value creation that are no longer fulfilled by their historically grown value networks. Since the change from a pure manufacturer to a Smart Service provider is a challenging task, companies may follow a strategy-driven transformation process. Planning and realizing such a transformation process require anticipated effects of future value creation as Smart Service Provider on a company's current value network. This is the basis for planning strategic transformation initiatives with corresponding goals. The paper at hand addresses these issues with a methodology for an in-depth analysis of the effects of Smart Services on value creation. It consists of four consecutive phases: initial analysis, effect analysis, in-depth analysis and implementation planning. The methodology is validated by four case studies from tooling machine industry.

Keywords: digitalization, servitization, smart services, value offering, value creation, impact analysis, in-depth analysis, methodology

1 Smart Services as a Synthesis of two Megatrends

For an extended period of time, the manufacturing industry was characterized by mass production, division of labour and rationalized business processes (Nickel, 2013). But currently, it is undergoing an extensive change in value creation due to two trends: servitization and digitalization (Frank et al., 2019), (Lerch and Gotsch, 2014).

Servitization is basically understood as adding value by supplementing products with services (Baines et al., 2009). Services are particularly attractive for manufacturing companies, because they enable new sales opportunities with constant payment flows and allow differentiation in markets (Herterich et al., 2016), (Lerch and Gotsch, 2014). Whereas a manufacturer pursues products as core business, a services providing manufacturer complements it with additional services. Manufacturing service providers, on the other hand, define services as their explicit core business (Schuh et al., 2004).

Digitalization describes the increasing interconnection of products and machines through new possibilities in information and communication technology (Acatech, 2015). There are two main developments: the internet of data and services and the internet of things. The internet of data and services describes the change in use from central computers and data warehouses to big data, cloud computing, and smart devices. The internet of things means the use of cyber physical systems instead of simple, physical objects or even just embedded systems (Gausemeier et al., 2015), (Paukstadt et al., 2019). As figure 1 illustrates, the described megatrends converge. This results in completely new business and market opportunities for manufacturing companies.

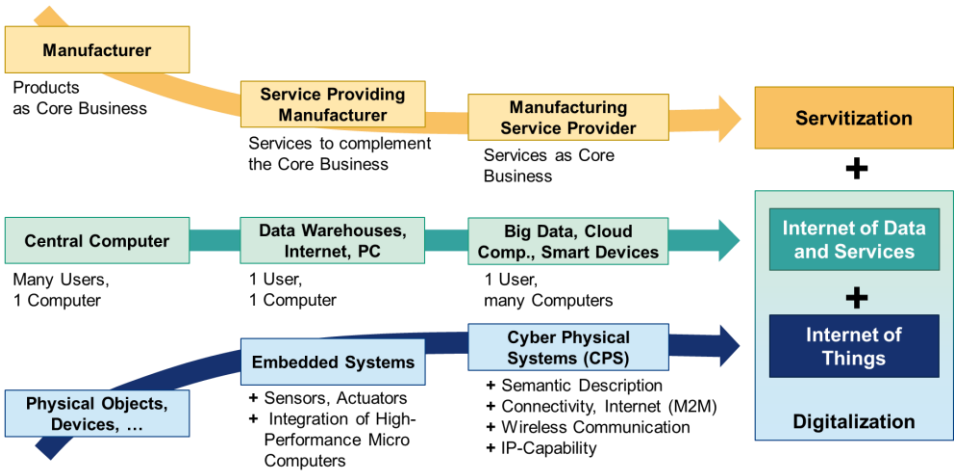

Figure 1 Converging two Megatrends of servitization and digitalization inspired by Gausemeier et al. (2015), Schuh et al. (2004)

The convergence of servitization and digitalization enable new forms of hybrid market offerings. Smart Services are a certain type of data-based services. The term Smart Service originates from an evolution of various terms such as Teleservices, Remote Diagnostics or Remote Services (Grubic, 2014). The focus in the definition of the term was mainly on the term remote, which was intended to emphasize the spatial separation of service provider and recipient (Klein, 2017). The further development of the

concept of Smart Services goes back to Allmendinger and Lombreglia, who used it to describe a digital service that is connected to an intelligent, networked object - i.e. a cyber-physical system - and is provided via it. The networked object hereby processes information about its own state and the state of its environment (Allmendinger and Lombreglia, 2005). A synthesis of further definitions leads to the understanding of the term, according to which a Smart Service is a digital service based on the (usage) data of a cyber-physical system (Koldewey et al. 2019). Smart Services generate added value via continuous data collection and analysis (Paluch, 2017). They stand out from traditional maintenance and upgrade offerings bundled with physical products. Increased cost efficiency for the providing company and individual added value for the customer are further characteristics of Smart Services (Allmendinger and Lombreglia, 2005).

On the one hand, Smart Services open up a wide range of opportunities to manufacturing companies. On the other hand, Smart Services lead to change in value creation that needs to be examined more detailed.

2 Changes in Value Creation

As discussed above, Smart Services represent a highly complex hybrid market offering, understood as a response to the tension between digitalization and servitization. The development, provision and billing of Smart Services often posess great challenges for companies, since their existing value creation is only suitable to a limited extent. The business with Smart Services requires adjustments in value creation; both within the offering company and across companies (Chowdhury et al., 2018). These effects are discussed below.

Internal Value Creation Changes

As Porter (1986) suggests, internal value creation is understood as a logical sequence of activities to generate market offerings. This so-called Value Chain consists of primary activities and supporting activities. Primary activities directly contribute to the value creation of goods and services (e.g. production and manufacturing, logistics or customer service). Supporting activities, however, provide essential resources (e.g. IT infrastructure). Digitalization and servitization strongly influence both primary and supporting internal activities (Porter, 2014).

Against the background of digitalization, the change in production and manufacturing is obvious. New hardware components as sensors and the necessity of software components change products themselves as well as complemental value creation processes (Böllhofer et al., 2015). In addition, logistics are faced with major challenges due to short delivery times, small lot sizes and a high degree of individualization. Digitalization enables new solutions, e.g. monitoring with built-in sensors for controlling and optimizing material flows as flexible and efficient as possible (Autonomik, 2017). According to Benkenstein and colleagues (2014), companies no longer just deliver products but support their entire life cycle. Activities are extended to include commissioning at the customer's premises, support for recurring use and subsequent disposal. Furthermore, with the help of digitalization, the evaluation of usage and condition data can provide economic benefits for both parties. Customers may not have to

pay for additional services and suppliers have more flexibility since resources are only used in the actual case of use (Benkenstein and Waldschmidt, 2014).

The influence of data and its use extends through all activities considered. The infrastructure fulfils the task of adapting appropriate internal IT systems (e.g. systems for customer relationship management) or connections to external systems (e.g. platforms) according to requirements or providing them completely (Autonomik, 2017). As Kammler and colleagues (2019) determine, Smart Services require their own data-driven value chains. These are divided into the three phases: 1) Data retrieval from Sensorial Equipment, 2) Analysis of Raw Sensor Data and 3) Integration of Services and Event Information (Figure 3). The last phase in particular is considered to have a high value creation potential, since service execution can be triggered automatically and event-driven (Kammler et al., 2019).

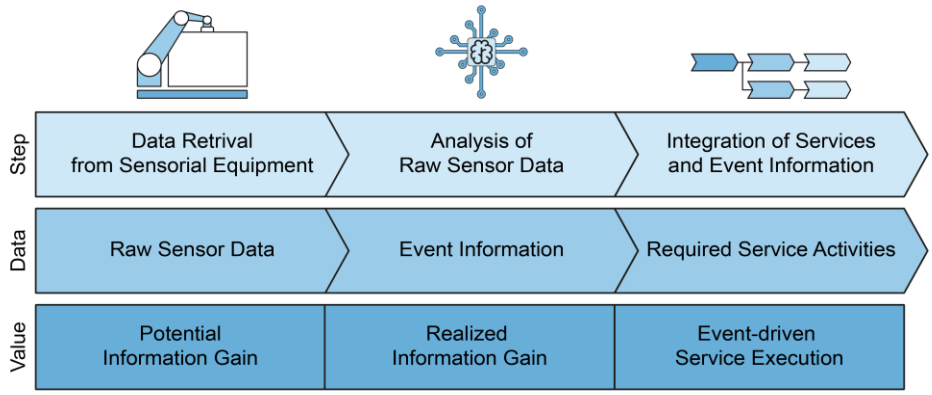

Figure 2 Data-driven value chain according to Kammler and colleagues (2019)

However, a company is not a closed system. Rather, the classical value chain and the data-driven value chain both are interlinked with the environment (Husen, 2015), (Bach et al., 2017).

External Value Creation Changes

As Porter already proposes, specific links and relationship between companies combine them into so-called value networks. Products or services are passed on as output of the own value chain to other companies to reuse them for their own value creation (Porter, 2000). According to Bach and colleagues those activities of value creation that can be provided more cheaply, more quickly or with higher quality by other companies must be performed externally (Bach et al., 2017).

For the development, provision and billing of Smart Services, the change from rigid value chains to open value networks is essential. Physical and virtual activities merge and information, resources or objects are connected with each other. Customers are actively involved in value creation. New forms of cooperation become feasible (e.g. remote maintenance of machines and systems by experts from the manufacturers) (Acatech, 2015), (Gotch et al., 2018), (Mittag, 2019).

Digital platforms and service platforms deserve special mention as outstanding assets in the value creation for Smart Services. Digital platforms cause major disruptions and radical changes in the value creation of entire industries (Pöppelbüß, 2017). Digital ecosystems are emerging that follow their own economic mechanisms and offer a wide range of opportunities for the development of innovative business models (Fortiss, 2016) The implementation of such business models, in turn, requires typical roles of value creation (e.g. platform owners, suppliers, producers, consumers, and partners) (Drewel et al., 2017). The increasing penetration of service platforms requires entrepreneurial mediation and coordination skills in value networks. As intermediaries, platform companies occupy interfaces between customers and producers. Companies connected to the platform run the risk of being interchangeable too easily and losing data sovereignty (Engels et al., 2017), (Piller et al., 2017), (Mittag et al., 2017).

Figure 4 illustrates the growing complexity of value creation from product to Smart Service using the example of a German machine manufacturer. The value creation of a vertical milling machine is realized by a rigid chain. On the next level of complexity, a web-based teleservice already includes machine users in value creation. The highest level of complexity is achieved with an IoT platform for the realization of multiple Smart Services combined with a multisided market platform (Wortmann et al., 2019). A value network is required that includes many different and constantly changing participants.

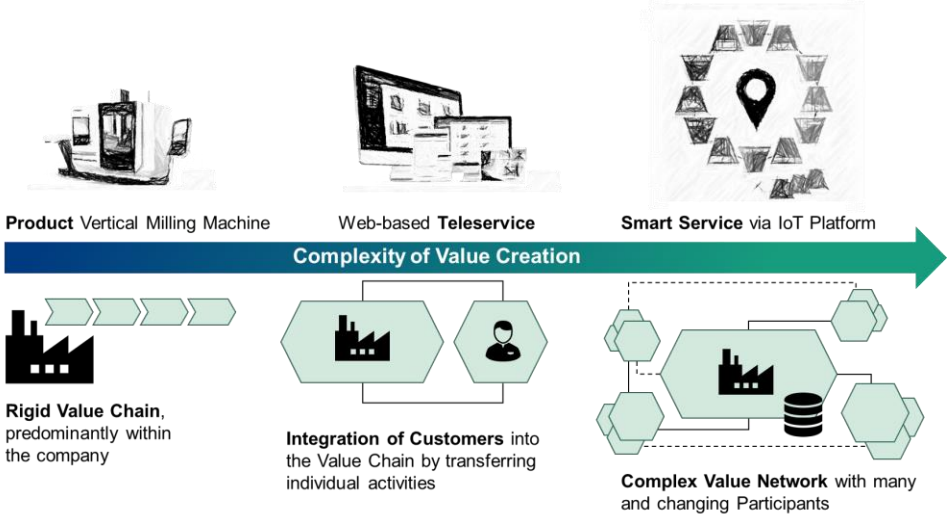

Figure 3 Increasing complexity of value creation for Smart Services with the example of a German machine manufacturer

3 Transformation to a Smart Service Provider

As previous sections show, the change from pure manufacturers to Smart Service Providers is a challenging task that addresses both internal and external value creation changes. This transformation requires a clear vision of how the future value creation of

the company as a Smart Service Provider will be shaped. Based on this vision, impacts on the existing value creation as a manufacturer may be anticipated. With this knowledge, strategic transformation goals and initiatives are defined, which determine the transformation process. Strategic transformation goals and initiatives are part of an overarching Smart Service strategy that leads the transformation process (Gausemeier et al., 2014), (Koldewey et al., 2019). Figure 5 illustrates the strategy-driven transformation process from a pure manufacturer to a Smart Service Provider.

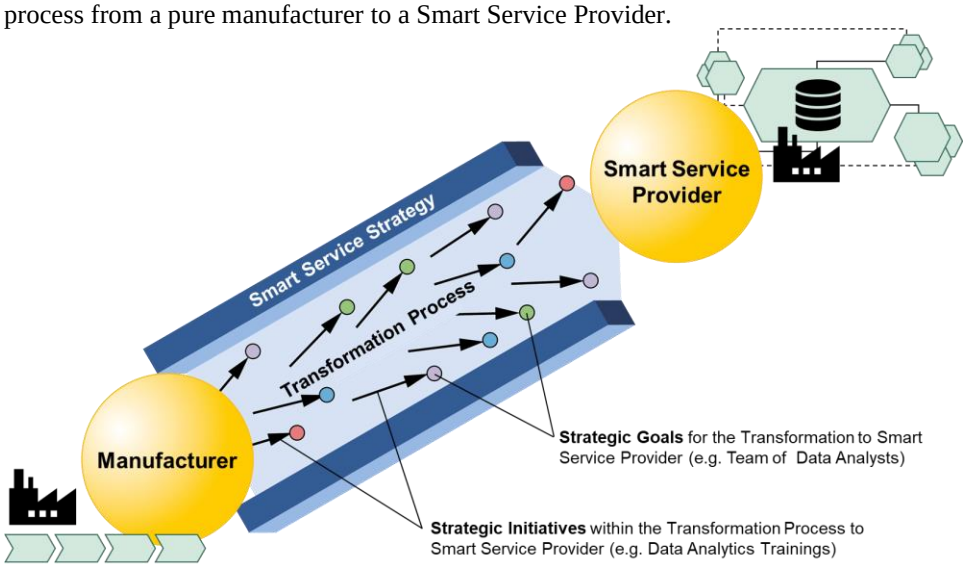

Figure 4 strategy-driven transformation process to a Smart Service provider inspired by Gausemeier (2014) and Koldewey and colleagues (2019)

In order to structure the field of action for designing the transformation process to a Smart Service Provider, we have developed a holistic framework for the planning of Smart Services (Figure 6). It is based on our experience from various consulting projects and our research activities regarding Smart Services (Koldewey et al., 2019). It consists of nine elements, which are arranged on the three levels of value orientation, value offering and value creation.

At the value orientation level, the strategy for Smart Services is defined regarding the future-oriented business structure of the considered company. It determines which markets are served with which market offerings and how the value is generated generally.

The market offering and business model for Smart Services refer to the value offering level. As the market offering describing the use case and specifying technical characteristics of the Smart Service. The business model is an aggregated representation of the business logic and describes how the company creates, mediates and accounts for value with the market offering. The value creation level contains the elements scope of work, organizational structure, operational structure and interactions. The scope of work comprises the necessary work content and conditions for the successful provision of Smart Services. The organizational structure represents the detailed functional framework of the company for the development, provision and billing of Smart Services. Within the operational structure, the business processes for the development, provision and billing of Smart Services in the company are considered. interactions describe the cross-company

relationships that are essential for success as a Smart Service provider. The integration of the data-based services into IT systems is a cross-sectional topic in the company under consideration. New competence requirements also form a cross-sectional topic and occur in the most diverse business areas (Frank et al., 2019).

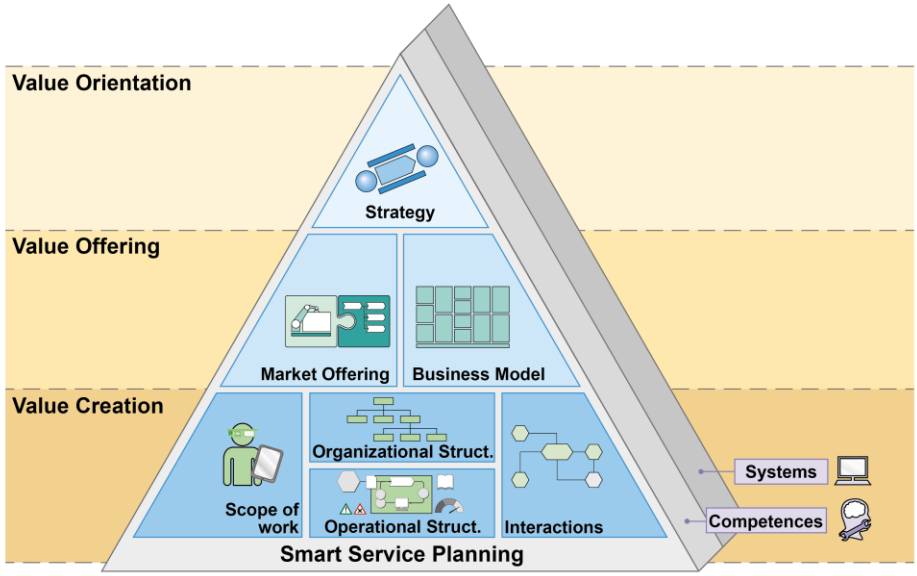

Figure 6 Framework for the planning of Smart Services according to Koldewey and colleagues (2019)

However, the planning and design of these elements on their own is not sufficient to define strategic goals and initiatives for the transformation process to become a Smart Service Provider. This requires a closer examination and analysis of the effects of the value proposition of a future Smart Service provider on the existing value creation of a company.

There are various approaches in literature that address this challenge. For an example, Schneider's specification technique provides a holistic and interdisciplinary approach to the description and analysis of value networks, but only partially considers the elements for planning Smart Services (Schneider, 2018). The systematic for designing the value creation for hybrid market offerings by Mittag includes the analysis of the effects of market offering and business model on value creation. However, the elements IT Systems and competences as well as the underlying Smart Service strategy are not taken into account (Mittag, 2019). In addition, there are other approaches to the analysis of the value creation of a company (Bach et al., 2017), (Erlach 2013). Some basic approaches to impact analysis would need to be adapted in the context of Smart Services with unknown effort (Ahsen et al., 2010), (Gausemeier et al., 2014), (Anderl et al., 2015). To the best of our knowledge, there is no approach that address the challenges identified in planning the transformation to a Smart Service provider completely. Therefore, there is a need for action to develop a Method for the in-depth Analysis of value creation changes through Smart Services.

4 In-depth Analysis of the Effects of Smart Services on Value Creation

In this chapter the research approach is discussed on which the developed methodology is founded. Subsequently, the developed methodology is briefly presented with the help of its four-phase process model. Each phase is described in detail and a consistent example is given for clarification

The methodology was developed at the University of Paderborn using the Design Research Methodology (DRM) according to Blessing and Chakrabarti (2009). The DRM consists of four phases: 1) Clarification of the research goal, 2) First descriptive study (DS I), 3) Prescriptive study (PS) and 4) Second descriptive study (DS II). The clarification of the research goal includes the definition of the theoretical foundation, the state of the art and the definition of the goal. The first descriptive study leads to a deeper understanding of the problem and the requirements for the methodological support derived from theory and practice. The methodology is developed during the prescriptive study and is based upon the experiences and requirements from DS I. The second descriptive study consists of the evaluation in practice. By applying the methodology, need for improvement is derived. The research was conducted in the joint research project Instruments for pattern-based planning of hybrid value creation and work for the provision of Smart Services (IMPRESS). In addition to the University of Paderborn, 2 other research institutes and 7 mechanical and plant engineering companies are participating in the project.

The result of the research is a generic methodology for the analysis of the effects of Smart Services on value creation. It consists of four phases: Initial Analysis, Effect Analysis, In-depth Analysis and Implementation Planning (Figure 7). In the following the methodology is briefly summarized and later described in detail using examples out of the four case studies with mechanical engineering partners in the project.

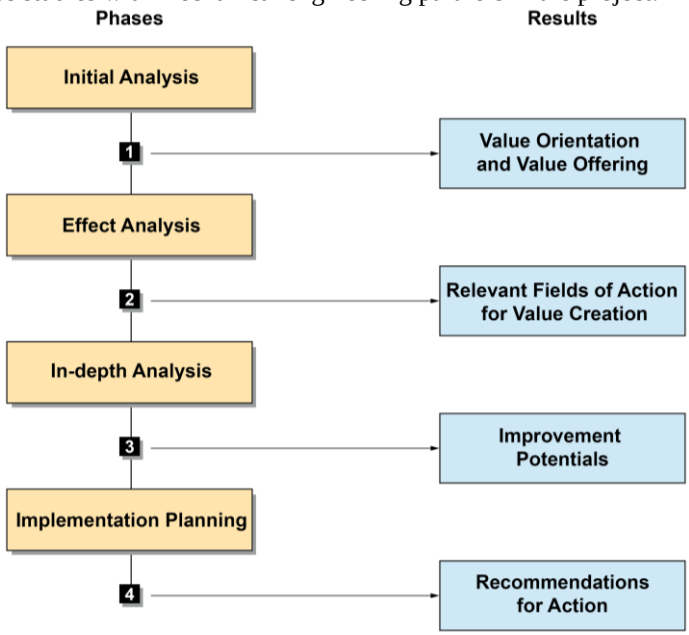

Figure 7 Process model for the in-depth analysis of the effects of Smart Services on value creation

In the first phase the value orientation and value offering as a future Smart Service provider is analysed. Within the second phase a Quick-Check workshop is executed and evaluated to identify relevant fields of action for adapting value creation. In the third phase, the affected fields of action in value creation will be analysed with an In-depth Analysis. Therefore, a collection of tools is used that are suitable for the challenges of the affected fields of action. In the last phase, identified improvement potentials for the future value creation are prioritized. The result of the methodology are recommendations for the planning of the transformation to a Smart Service provider.

Phase 1: Initial Analysis

The aim of the first phase is to clarify the future value orientation and value offering as a Smart Service provider. Therefore, the elements strategy, market offering and business model are developed and documented together with the company planning to become a Smart Service provider. Various instruments such as strategy portfolios or the business model canvas (Osterwalder and Pigneur, 2010) are used to detail the elements. Figure 8 shows an extract of relevant questions for the elements strategy, market offering and business model.

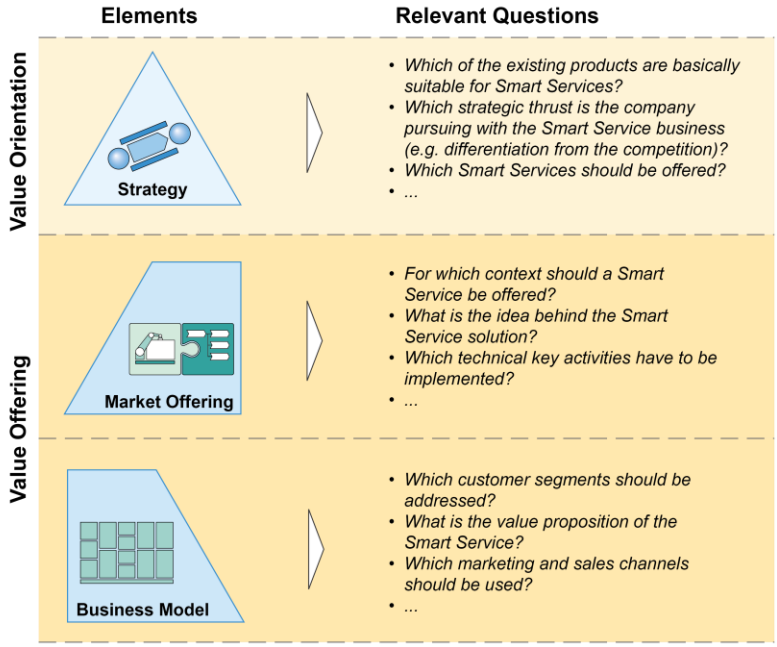

Figure 8 Extract of relevant questions to detail Smart Service strategy, market offering and business model

In order to describe the value orientation of a company in more detail, questions are posed that are based on Who, What and How. In particular, the Smart Service strategy is detailed with the help of superordinate questions (e.g. *Which of the existing products are basically suitable for Smart Services?*). At the value offering level, the examination is more precise. Specifying the market offering requires technical information and corresponding questions (e.g. *Which technical key activities have to be implemented?*).

Relevant questions for the business model refer to the partial models of the business model canvas (e.g. *Which customer segments should be addressed?*).

The result of the first phase is the documentation of a clear vision of how the considered company use to provide Smart Services. This is the basis to analyse the effects of Smart Services on the current value creation of a company.

Phase 2: Effect Analysis

The aim of this phase is to identify the relevant fields of action for value creation as a Smart Service provider in order to execute a subsequent in-depth analysis. For this purpose, we developed a Smart Service Quick-Check enabling manufacturing companies to identify those areas of value creation that may need to be adapted for the provision of Smart Services. The Smart Service Quick-Check consists of a questionnaire and a two-part workshop concept.

The Quick-Check questionnaire is divided in three dimensions regarding the elements of strategy, market offering and business model. Based on a comprehensive literature review, analyses of maturity models regarding digitalization and Industry 4.0, and workshops during our four case studies, we identified 122 transformation drivers that describe general effects in value creation for Smart Services. Out of these we extracted and summarized 43 questions each one addressing at least one transformation driver. The questions are formulated in such a way that it checks whether the company has already identified this Transformation Driver and initiated actions or not. Consequently, the possible answers are limited to yes and no, as shown in Figure 9. If one question is answered negatively, this is a field for action that is subject to the in-depth analysis. In addition, the relevance of the field of action is evaluated in order to analyse only those fields of action that are highly relevant. Since the effort of an in-depth analysis can be considerable, this prioritization is necessary.

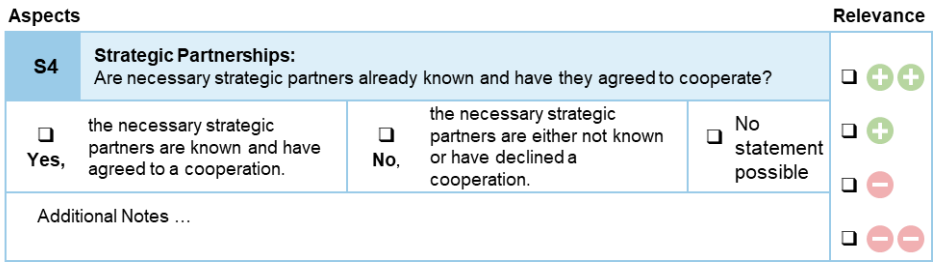

Figure 9 Question design from Smart Service Quick-Check questionnaire (excerpt)

The dedicated workshop concept consists of two parts and can be split into one or two days depending on the progress of the company in its Smart Service transformation. The first part serves to create a common understanding of the value orientation and offering of the company. Additionally, the existing value creation is documented rudimentary regarding the elements scope of work, organizational structure, operational structure and interactions. In the second part, the workshop participants are guided through the Quick Check in a moderated manner and assistance is provided in answering each question. In this way, we ensure that the Quick Check can be completed by every manufacturing company.

The result of the phase are relevant fields of action for the future value creation of the considered company planning the transformation to a Smart Service provider. In order to derive concrete recommendations for action for the company, an in-depth analysis is required for each field of action.

Phase 3: In-depth Analysis

The basis for the In-depth Analysis is the executed and evaluated Smart Service Quick-Check. The aim for the third phase are improvement potentials for the future value creation resulting from an In-depth analysis of the relevant fields of action. The phase consists of two consecutive steps explained in the following.

In a first step, an In-depth analysis tool is selected for the relevant field of action. For the analysis of all effects on value creation, a multi-method approach is used, which comprises several analysis tools from different application contexts. An overview of all in-depth analysis tools is provided by an assignment matrix (Figure 10). In the present paper 27 tools for In-depth Analysis were identified, as listed in the columns. The rows represent the 43 relevant Transformation Drivers queried in the Smart Service Quick-Check. In addition to the basic application, the assignment matrix also assesses the suitability of a tool for the Transformation Driver under consideration. A distinction is made between full suitability as “X” and conditional suitability as “(X)”. The In-depth Analysis tools are validated methods from science and practice and come from different disciplines, such as quality management, strategic planning, systems engineering or project management. For each tool, a two-page profile is provided containing essential tool characteristics and facilitates its use (e.g. the Specification technique for the Description and Analysis of Value Networks according to Schneider (2018)).

In a second step, the potential for improvement for the future value creation is identified. For an example, by applying the specification technique for value networks an entire inter-company value network may be modelled and enables detailed analyses of potentials and risks.For example, this revealed that one of the considered companies stands in a dependent relationship with a certain retailer, occupying the interface to the customer. The identified potential for improvement is therefore *"Establishing a Cooperation with a Platform Operator"* in order to reach the customer with digital services and to be able to build up the Smart Service business.

Overall, we identified 35 Improvement Potentials when analysing the considered company in-depth. In order to derive recommendations for action for the implementation of the identified potentials, these are to be examined more detailed.

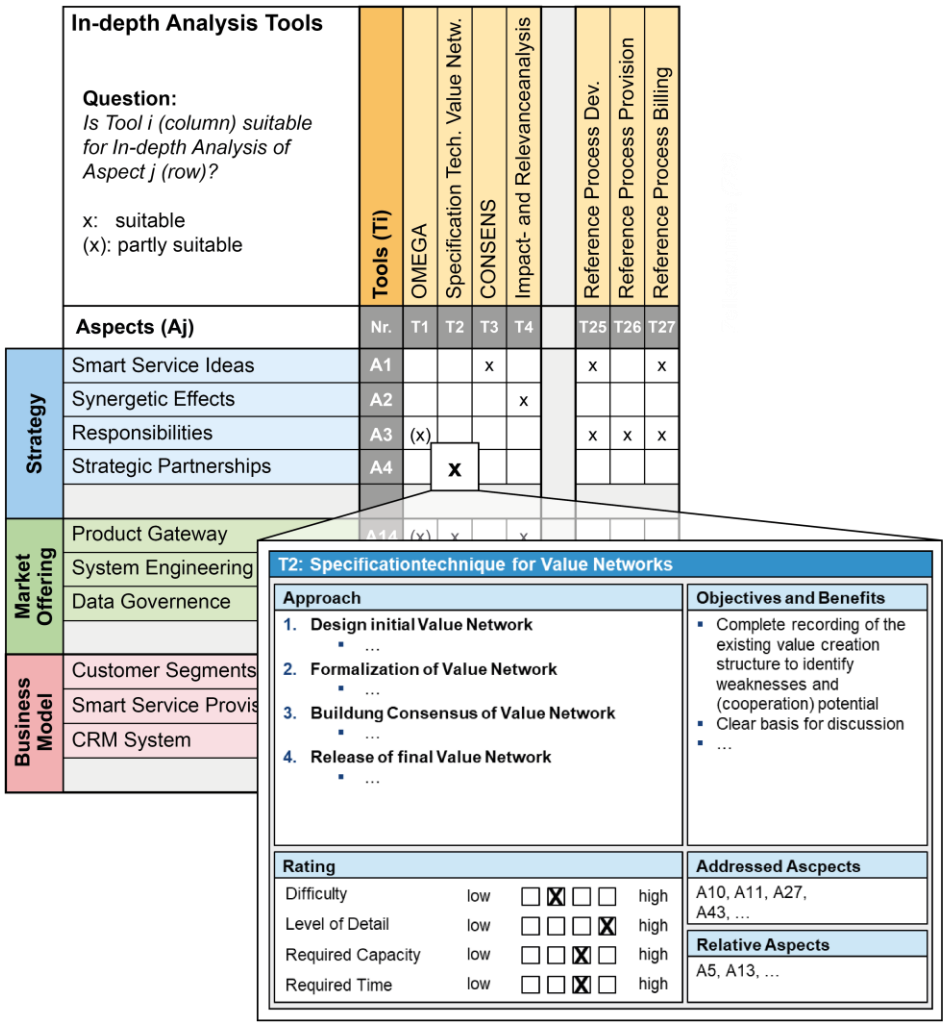

Figure 10 In-depth analysis tools and relevant aspects

Phase 4: Implementation Planning

In the last phase, all identified improvement potentials are prioritized. The aim of this phase are recommendations for the planning of the transformation to a Smart Service provider.

Therefore, the analysis of the systematic behaviour according to Gausemeier and Plass (2014) is used in a first step. The influence analysis enables the determination of interconnections between the individual improvement potentials. In addition to direct relationships, indirect influences on several improvement potentials are investigated as well. In this way, even complex relationships between the improvement potentials are examined. The influence analysis leads to an active-passive-grid, which is shown in Figure 11 as an extract of the improvement potentials for strategy dimension.

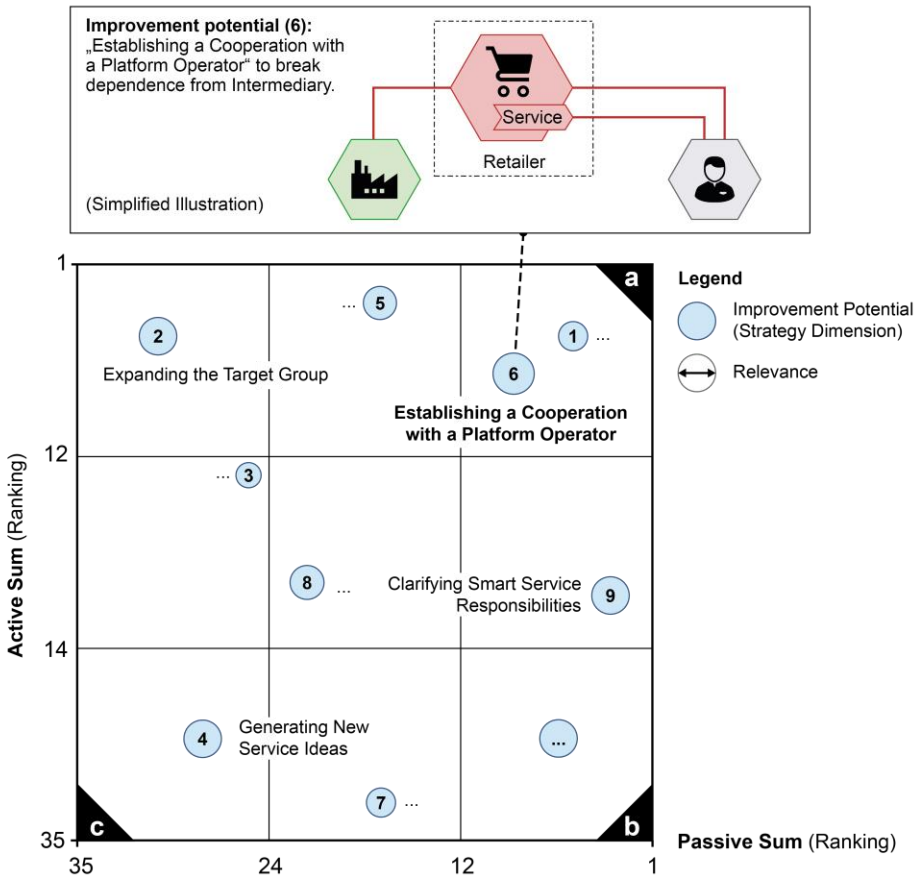

Figure 11 Active-passive-grid for improvement potentials (excerpt for strategy dimension)

The active-passive-grid comprises two dimensions: Active sum and passive sum. The active sum indicates how strongly one improvement potential affects the other improvement potentials. The passive sum shows how strongly one improvement potential is influenced by others. We assume that the implementation of improvement potentials with high active sums basically supports the implementation of others. Additionally, the active-passive-grid also represents the relevance for Smart Service transformation of each improvement potential from the company's perspective. The higher the diameter of an improvement potential the more relevant it is. Hence, especially those improvement potentials are to be prioritized that have a high relevance as well as a high active and passive sum.

As an essential result of the last phase, manufacturing companies receive a recommendation for action pointing out which improvement potential should have the highest priority in its implementation. In addition, a logical sequence can be derived from the active-passive-grid, according to which the overall transformation process is to be

designed. Strategic transformation goals and initiatives can be defined and scheduled in order to reach the vision of a Smart Service provider.

5 Summary and Conclusion

The manufacturing industry is currently undergoing a profound change in value creation. Two trends in particular are responsible for this: digitalization and servitization. In response to these two trends, hybrid market offerings, so-called smart services, are becoming increasingly important. The implementation of successful Smart Service offerings turns out to be a very demanding task for manufacturing companies. Their historically grown type of value creation is only suitable to a limited extent for developing, providing and billing Smart Services. This requires a transformation process to become a Smart Service provider. Regarding the initiation of the transformation process, the effects on value creation must be examined in more detail in order to identify relevant fields of action for the value creation design.

With the paper at hand, we propose an approach to fill this research gap. First, we introduced an adapted framework for Smart Service Planning, consisting of nine elements arranged on the two levels value offering and value creation. Second, our methodology builds up on the framework and provides a process model for the In-depth Analysis of value creation through Smart Services with recommendations for the future design of value creation as a Smart Service provider as results.

During our research and accompanying project work we made general findings as well: 1) We identified the importance of an In-depth Analysis to adequately analyze effects of Smart Services on value creation in our case study. 2) During our case study, we found that the challenges faced by all four participating companies were highly diverse, but some first solutions we identified seem to be similar and may be summarized to patterns. Hence, further methods and tools to design value networks for Smart Services individually are needed. 3) Once the transformation process is started, the corresponding value network evolves. A methodological approach managing its progress and success does not exist and related tools are missing.

6 Acknowledgement

The research findings in the paper at hand were conducted in the joint research project Instruments for pattern-based planning of hybrid value creation and work for the provision of smart services (IMPRESS). In addition to the University of Paderborn, 2 other research institutes and 7 mechanical and plant engineering companies are participating in the project. The IMPRESS project (02L17B070) is/was funded by the Federal Ministry of Education and Research and the European Social Fund within the context of the programme “Innovations for tomorrow's production, services and work: the future of work” (“Innovationen für die Produktion, Dienstleistung und Arbeit von Morgen: Zukunft der Arbeit”).

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