IMPROVING SERVICE VALUE CREATION FOR MANUFACTURING SMEs BY OVERCOMING DATA SHARING HURDLES IN ECOSYSTEMS

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ABSTRACT

Purpose:

Although there is an apparent potential in using data for advanced services in manufacturing environments, SMEs are reluctant to share data with their ecosystem partners, which prevents them from leveraging this potential. Therefore, the purpose of this paper is to analyse the reasons behind these resistances. The argumentation paves the way for elaborating countermeasures that are adequate for the specific situation and the typical capabilities of SMEs.

Design/Methodology/Approach:

The analysis is based on literature research and in-depth interviews with management representatives of 15 companies in manufacturing service ecosystems. Half of these are manufacturers and the other half technology or service providers for manufacturers. They are SMEs or partly larger companies operating in structures that are typical for SMEs.

Findings:

Data sharing hurdles are investigated in the five dimensions, 1. quantifying the value of data, 2. willingness to share data and trust, 3. organizational culture and mindset, 4. legal aspects, and 5. security and privacy. The ability to quantify the value of data is a necessary but not sufficient precondition for data sharing, which must be enabled by adequate measures in the other four dimensions.

Originality/Value:

The findings of this empirical study and the solution approach provide an SME-specific framework to analyze hurdles that must be overcome for sharing data in an ecosystem.

Manufacturing SMEs can apply the framework to overcome the hurdles by specific insights and solution approaches. Furthermore, the analysis illustrates the future research direction of the project towards a comprehensive solution approach for data sharing in a manufacturing ecosystem.

KEYWORDS: smart service ecosystems, data-driven value creation, data sharing, data-driven organization and culture, data governance.

1. INTRODUCTION

With the concept of servitization of manufacturing, industrial value creation is shifted from the goods perspective to the service perspective. Mutual value is created in the interactions between providers and beneficiaries (Kowalkowski & Ulaga, 2017; Lightfoot et al., 2013; Vargo & Lusch, 2008). This leads to the concept of product services systems (PSS) (Oliva & Kallenberg, 2003; Tukker & Tischner, 2006). The advances of the industrial internet of things and digitalization enable and foster this transformation from products to services, which manifests itself, for example, in the concept of Industry 4.0 (Thoben et al., 2017; Weimer et al., 2016). Data science and related technologies are relevant factors for the provision of advanced services (Paschou et al., 2020).

As elaborated in (Meierhofer et al., 2019), utilizing data for service value creation is a significantly higher hurdle for SMEs than for large enterprises. This represents a challenge in particular for SMEs in terms of soft factors such as knowledge, organisation, and culture. However, also hard factors such as legal and security concerns as well as profitability issues are a barrier to the adoption of data-driven services. This paper discusses the studies carried out in the project "Data Sharing Framework" (Data

Sharing Framework, 2021) and the solution approaches that are developed. The project aims to support small and medium-sized enterprises (SMEs) in the Lake Constance region (Austria, Germany, Switzerland) in the cross-company and cross-border exchange of data for value creation. Practical and SME-friendly tools are developed in the following five perspectives: 1. quantifying the value of data, 2. willingness to share data and trust, 3. organizational culture and mindset, 4. legal aspects, and 5. security and privacy. The paper provides an empirical analysis of these perspectives. For the specific perspective of data value, it elaborates a solution to overcome the hurdle by a quantitative validation approach that is adequate for an application by SMEs.

2. RESEARCH METHODOLOGY

The data sharing framework presented in this paper is elaborated based on a literature review on hurdles for sharing data. The topic is investigated independently in the five dimensions. Accompanying the literature review, a field study based on interviews with totally 15 firms was conducted. The cases selected for the interviews were manufacturers being providers or customers of data-driven services or products on the one hand or technology and service providers for such firms. The interviews were conducted with managers responsible for marketing or development of smart products and services.

Given the analysis of the hurdles for data sharing, drivers and solution approaches to overcome these are sketched in the five dimensions. Specifically for the dimension “quantifying the value of data”, an initial solution proposal is additionally developed.

3. FINDINGS

3.1 QUANTIFYING THE VALUE OF DATA

As elaborated in (Meierhofer et al., 2022) and based on (Breuer et al., 2018; Möller et al., 2017; Moody & Walsh, 1999), the value of data can be approached by three perspectives: 1. the market value of the data, 2. the value based on the cost to create and process the data, and 3. the value that arises when data generates benefits in an application context, typically by means of data-driven services (functional value). In this paper, the third perspective is used for the further study. The interviews made obvious that the firms have an awareness of the value of data, but do not dispose of the methods, resources, or competences to determine it quantitatively (Meierhofer et al., 2022). If the value of the data is known quantitatively, firms can make better decisions about investing in sharing and utilizing data.

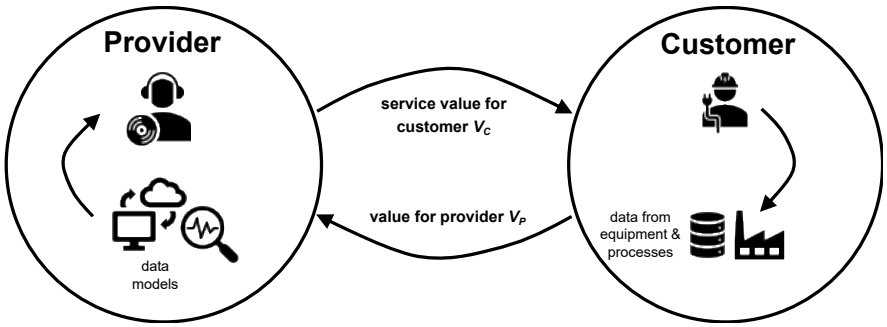

Figure 1: Value creation model (adapted from (Meierhofer et al., 2022))

Data is created by customers from operating equipment and processes (Figure 1). The focus is put on the dyadic value exchange between two actors, keeping in mind that this concept can then be extended to an ecosystem perspective in future research. This data contains information on the physical condition of the equipment, its operations as well as quantities and time information (e.g., work flow time stamps, durations) of the processes. The resulting smart, connected product (Porter & Heppelmann, 2014) enables mutual value creation by data-driven services. Considering only the additional effects by the data-driven services (i.e., neglecting benefits and costs stemming from the base product), the value V_C is created by the provider for the customer:

$$V_C = V_{C,peformance} - P_r - C_{C,service}$$

with $V_{C,performance}$ being the additional performance gained by the customer, $C_{C,service}$ the additional costs incurred for the customer by the service, and P_r price paid for the service by the customer. Please note that maximizing $V_{C,performance}$ does not necessarily mean getting the highest possible output of the equipment, but getting the most adequate performance given the operational requirements of the customer. The performance $V_{C,performance}$ incorporates both availability and failure rate. The additional value for the customer obtained by the service is reduced by price P_r paid to the provider as well as the customer's own process costs for operating the service $C_{C,service}$.

In the opposite direction, the value V_P is captured by the provider:

$$V_P = V_{P,peformance} + P_r - C_{P,service}$$

with $V_{C,performance}$ the providers' own performance gains by the data sharing and $C_{P,service}$ the additional costs incurred for providing the service. $V_{P,performance}$ includes effects such as reduced service costs, e.g., by remote service or by more efficient problem identification processes, as well as provider internal processes such as better marketing effectiveness thanks to data-driven, targeted marketing or better informed new service development processes thanks to data gathered from the installed base. Note that the variables in these equations and thus also V_C and V_P are time-dependent, which is relevant when taking into account that value is accrued over time along the phases of the customer or product lifecycle. To factor in this time dependency over the lifecycle in the value calculation, we consider the customer lifetime value accrued, i.e., $V_{P,tot} = \int_{T_L} V_P \cdot dt$ and $V_{C,tot} = \int_{T_L} V_C \cdot dt$ with T_L the duration of the lifecycle.

This concept for mutual value creation is implemented in an agent-based simulation model environment. The random nature of the system is modelled by implementing stochastic variables for the customer need as well as stochastic processes for the equipment health and the customers' behaviour. The equipment health is modelled by a finite state machine (Cassandras & Lafortune, 2021) by assigning every machine multiple health states such as: working, irregularity, fatal irregularity, maintenance and failed, which leads to stochastic service needs.

Figure 2: Performance over time as a function of data usage

In the simulation model, different levels of data-driven services can be activated. In the example in Figure 2, the average performance of the equipment in a base of 79 business customers with totally 185 machines is shown over a typical equipment lifetime duration of 10 years. Due to degrading equipment health, the performance decreases over these years. The graph shows the performance degradation for the case with no additional data-driven services (i.e., just standard services) as opposed to the cases with data utilization for remote services and for condition-based maintenance services. These functional improvements over time can easily be translated into financial improvements by applying cost factors, thus revealing the functional value of the data.

3.2 WILLINGNESS TO SHARE DATA - TRUST

Product-based data is created in all phases of the product life cycle and is the basis for companies to develop new data-based services, however, only if partners share this data (Vogt et al., 2021). One of the key drivers to enable data exchange in an ecosystem is the existence of trust between the partners. This study provides insights into how companies can increase trust especially with their customers in different dimensions. Trust building measures include leveraging key sales managers, engaging customers in a very early stage, and utilizing appropriate technical, regulatory and contractual tools.

Product-based data can either exchanged directly between the data provider (typically the user and/or the customer) and the data recipient, or is funnelled through a third party, e.g., a platform provider. The type of data being exchanged is predominantly sensor data but can also include environmental, quality, production, or maintenance data. Those companies who have already started to share data with partners identified several factors to create a so-called trusted setting for exchanging data in an ecosystem. Often, the first step is to set up a legal agreement specifying the terms and conditions for sharing data. Since the uncertainty regarding project scope is typically high at the beginning, it is recommended to utilize a "starter" legal agreement which specifies the main conditions such as regarding type and amount of data to be shared, as well as ownership and data storage. As the project progresses and the value of the shared data can be specified more clearly, it is then recommended to establish a full legal contract to clarify the financial aspects. Several companies mentioned the lack of data standards as a significant barrier to sharing data in an ecosystem. The utilization of common formats as well as appropriate ISO standards and certificates by partners in the ecosystem of course facilitates data sharing. The competence to store and process data for example can be acquired and documented by signing up to industry certifications with regards to information security management such as the ISO/IEC 27001 (*ISO - ISO/IEC 27001 — Information Security Management*, n.d.).

Studies show that companies new to data sharing often collect all kinds of data without knowing how or if they will be used (Janhunen, 2019) . In order to further facilitate exchanging data, all partners should make the purpose and specific goals of data acquisition transparent before they begin to share their data. Several interviewees recommended engaging directly with potential partners at an early stage, for example, through workshops and interviews. Last but not least the role of sales managers is recognized as being critical. In a B2B setting, trust in a sales manager strongly influences trust in the entire organization (Gansser et al., 2021). Manufacturing SMEs often cultivate long relationships with their customers, so it is no surprise that trust in a salesperson can often exceed trust in an organization. Consequently, sales managers are an essential part of a data-sharing project since they only recommend such solutions to their customers when they themselves recognize the value of data sharing. Interviewees mentioned the need to convince their own sales managers of the importance of data sharing as a prerequisite to persuading potential customers to start the process of data exchange.

3.3 ORGANISATIONAL CULTURE AND MINDSET

From an organizational culture perspective, making use of data fundamentally impacts how individuals and the organization as a collective think and act which indicates that working with data requires a specific data-dominant logic (Kugler, 2020). A number of steps refer to various levels of analysis and they refer to the individual, the organization and the ecosystem alike. The empirical data reveal, among others, firstly, that individuals and organizations explicitly recognize the potential value of data in general and especially sharing the data across the ecosystem, Secondly, individuals and organizations need to think and act in a holistic way that goes beyond internal and external boundaries of a single company. Internal and external company boundaries, for instance, become more fluid. In doing so, the ecosystem is recognized as an additional unit that is relevant for generating value from the data. In doing so, organizational structures, roles and processes need to be adapted to requirements for working and sharing data within the organization and with the ecosystem partners.

A first cultural hurdle for sharing data with stakeholders in ecosystems involves recognizing internal and external data as a potential source of value. Manufacturers often function using goods-dominant logic (Vargo & Lusch, 2006). However, the nature of data as a resource differs fundamentally from a

tangible product. While raw data have limited direct value for many companies, data aggregation, data analysis, and linking these data to company-specific knowledge may add value to data that are rare, difficult to imitate, or difficult to substitute (Barney, 1991). Such data could be used to achieve a sustained competitive advantage (Gupta & George, 2016) and it should be protected by specific strategies for sharing the data in an ecosystem (Kugler & Plank, 2022). However, the interviews also indicated that the potential value inherent to data is still unrecognized by many companies, although this could change; data might, for example, gain value when new knowledge is available.

While individuals who frequently deal with data (e.g., CIOs, CDOs) are aware of the inherent value, others (e.g., sales and marketing managers) are still data illiterate. Interviewees reported two activities that seem to confirm this dilemma: While businesses hesitate to share their data for fear it might lose any potential value (Kugler & Plank, 2022), individuals with access to useful data (e.g., sales managers) are unaware of how that data could be profitably used. In both cases, the data remain dormant.

A second hurdle to sharing data lies in how companies view their organization and how rigidly they draw internal and external boundaries. While the focus for many businesses lies in the company or department in question, data sharing requires companies to broaden their horizons. The interviews revealed that (raw) data must be linked to different types of organizational knowledge that reside in various disciplines or departments within an organization. Technological expertise for data analysis also requires a business-related perspective that creates a clear business case, especially when finding a value proposition and domain-related knowledge (e.g., a machine or manufacturing process). Only by combining these perspectives can data be turned into a marketable business model. At the same time, the interviews revealed that because sharing data involves two or more companies, it is necessary for all parties to work together to benefit from data sharing. Data sharing also requires close cooperation or co-creation with external parties with which potential benefits or data application can be discussed. Both cases indicate that sharing data requires companies to think beyond their traditionally established boundaries.

3.4 LEGAL ASPECTS

Structured data governance is key to data sharing, however, few companies are really prepared to it. Qualitative interviews with SME representatives drew a heterogeneous picture in their dealing with legal aspects related to external data sharing. The few companies that showed clear ideas and guidelines in their external handling of data had corresponding internal policies and processes or at least approaches to this purpose. From this observation stem the following thesis relative to legal frameworks for data sharing: “efficient and targeted data sharing in business transactions requires an internal data governance”. Guidelines for SME to establish such data governance should address three focus areas:

I. Data Asset Management:

As a basis for the internal legal assessment and handling of data, an internal data inventory should be carried out as a first step. In addition, the origin of any data must be identified to categorize it more precisely and classify its economic potential. This can be done, for example, by applying data valuation approaches as described in section 3.1 of this paper.

II. Data IP Management:

In the EU, especially in Germany and Austria, as well as in Switzerland, applicable law constituting proprietary rights on single datasets and unstructured data collections does not yet exist (cf. Vorwachs & Seege, 2018; Fritzsche, 2022; Czychowski & Winzek, 2022). However, data may fall indirectly under intellectual property law (namely as a database within the meaning of DIRECTIVE 96/9/EC (SCOPE, 1996, p. 9)) or may be protected as trade secret against unauthorized access (cf. Leistner, 2018; Schmidt & Zech, 2017; Krüger et al. 2020; Wiebe & Schur, 2019; Wiebe, 2017). Both possible legal positions should be assessed on a case-by-case basis.

Hence, data inventories should be examined to determine whether and for which data and data collections such rights could apply and what measures may need to be taken for protection (e.g., c.f. section 3.5). This applies in particular to strategically relevant data, the categorization of which may

result from the considerations in the preceding sections 3.1 to 3.3. The resulting implications on contractual terms in data sharing agreements must then be taken into account within the following processes of “Data Contract Management”.

III. Data Contract Management:

For the reasons stated above, non-personal data is currently largely subject to contractual freedom. It is possible to legally protect shared data by means of contractual provisions. However, such contractual rights and obligations apply only to the respective contractual parties and therefore do not constitute exclusive rights effective against any third party.

Careful consideration should be given to which rights to which data should be granted to whom. This makes the data inventories even more important.

Companies should therefore establish guidelines for contracts or provisions governing the sharing of data. In this context, it is particularly worth considering to distinguish open data sharing policies (e.g., analogous to the concept of data altruism as part of the proposal for an EU Data Governance Act (European Commission, Proposal for a Regulation on European Data Governance (Data Governance Act), 2020) [c.f. Chapter IV "Data Altruism"] or to the established terms for open-source software) from restrictive contractual agreements on data sharing.

However, the currently existing broad contractual freedom for data sharing could face significant challenges with the implementation of the European Data Strategy and, in particular, the European Commission's proposal for a regulation on harmonized rules for fair access to and use of data (EU Data Act) (European Commission, Proposal for a Regulation on Harmonised Rules on Fair Access to and Use of Data (Data Act), 2022) published on Feb 23rd, 2022. The multisector approach of the EU-Data Act Proposal could have broad implications for companies inside and outside the EU. Almost every company that processes user generated data (within the definitions of Article 2 EU-DA Proposal) or places products or services on the market in the EU or that makes data available to recipients in the EU would potentially be affected by the EU Data Act (c.f. Article 1 EU-Data Act Proposal). This gives reason to assume that the EU-Data Act could have a comparably far-reaching impact as the GDPR.

3.5 SECURITY AND DATA PRIVACY CONSIDERATIONS

(ICT) security, safety measure, and data privacy considerations must be taken into account when analysing and consolidating readily usable results for SMEs.

The European Commission's digital agenda identifies security as a core issue and even dedicates a separate chapter to it, Strengthening Trust and Security, which states: "The European Commission's initiatives improve security while surfing the web and enhances trust and inclusion. It boosts the overall level of cybersecurity and fosters digital privacy in Europe." Embedded in the European Agenda on Security and the EU Cybersecurity Strategy, efforts are required from member states to increase trust in digital systems, as a high level of acceptance by the population is one of the basic prerequisites for successful implementation of the digital transformation, bridging the gap of private ICT security awareness and implementation of security measures within companies (Giannone & Santaniello, 2019).

For this reason, it is important that SMEs also have a well-founded and trustworthy IT security strategy for cross-company data exchange and can likewise align this with other stakeholders. Offering a common denominator to the possibly different strategic approaches of actors as well as raising awareness for the issue besides the necessary technical measures is the core challenge when addressing the hurdles of cross-company data sharing ecosystems (Heidt et al., 2019).

Traditionally and depending on the point of view of actors, a classification of security measures can be made with respect to a set of horizontal criteria. These traditional approaches to classify ICT security measures include the areas of (information) technical measures, structural measures, organisational measures, as well as personnel measures (Wegener et al., 2016).

When approaching classification according to areas of vertical application, distinctions are made between measures that are to be used organisation-wide, in parts of the organisation, or across company borders. Concrete vertical measures include establishment of an Information Security Management Strategy (ISMS) process and creation of information security policies; organisational

measures (e.g., control of resources, documentation, separation of roles); Checking IT security measures for compliance with information security policies (security compliance checking) as well as auditing; Response to security-relevant events (incident handling); Personnel related measures (incl. training and formation of security awareness); Structural security and infrastructure; Emergency preparedness and ICT resilience; as well as system-specific measures (Giannone & Santaniello, 2019).

Hereby the selection of system-specific measures depends to a large extent on the type of ICT system to be protected. Emergency preparedness and ICT resilience is measured against basic threats against ICT systems (loss of confidentiality, integrity, or availability).

For these reasons and in accordance with said classifications as well as the differentiation of horizontal and vertical measures, in our framework for data sharing services we include the provision of methods for minimising ICT security risks when sharing data across SME company borders (assessment, categorisation, and minimisation), determination of the suitability of norms and standards (e.g., ISO norms, BSI guidelines) as well as the promotion of data security by providing a set of readily available solutions and adequate, tailormade best-practices (certifications, further training measures, methodological competences, legal requirements guidebooks).

4. CONCLUSIONS AND OUTLOOK

In this paper, we discussed the hurdles and solution approaches for data sharing among manufacturing SMEs from five different perspectives: 1. It turned out that the firms know in principle that the data available in their ecosystem is of value, but cannot quantify it and therefore have an uncertain foundation for making targeted investments in data-driven services. Therefore, assessing this value quantitatively is a necessary prerequisite for enabling data sharing. From the perspective of service value creation, the functional benefit in business processes that can be achieved has a predominant role. Therefore, a process-based value model was developed and described quantitatively in a mathematical way. For the numerical evaluation, an agent-based simulation model is an adequate means to assess different scenarios of using data. 2. In particular, trust needs to be established among the actors of the ecosystem, whereby trusted sales managers play a key role, for instance. 3. The organization needs to be ready to recognize data as a source of value and to shape less rigid internal and external boundaries in organizations. 4. From a legal point of view, establishing proper data inventories and managing data as an asset is essential, as it is expected that today's large contractual freedom is going to be changed substantially with the introduction of the EU Data Act. 5. Against this background, it is also essential that SMEs establish and implement a well-founded and trustworthy IT security strategy.

This research is limited by the fact that it investigates the five dimensions separately. Therefore, future research will focus on converging them to a coherent data sharing frameworks that creates a new theoretical and practical concept. Furthermore, this study started with an exploration of bilateral value exchanges, which needs to be expanded to an ecosystem perspective in the future.

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ACKNOWLEDGMENTS
This study was supported by the grant "ABH097" within the framework of the Interreg VI-programme "Alpenrhein-Bodensee-Hochrhein" (DE/AT/CH/LI) whose funds are provided by the European Regional Development Fund (ERDF) and the Swiss Confederation. The funders had no role in study design, data collection and analysis, decisions to publish, or preparation of the manuscript.
The authors would also like to thank ZHAW digital for the support of this work

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