



Value Co-creation in Data-Driven Product-Service Systems: An Industrial Perspective

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Abstract. Value co-creation is an important aspect for servitized companies operating a Product-Service System business. However, their relation to value co-creation might depend on where they are on the servitization journey. This paper described the result of a multiple-case study with three industrial partners and their perspectives on the challenges and opportunities with value co-creation for data-driven Product-Service Systems.

Keywords: Value co-creation · Data-driven design · Product-service systems

1 Introduction and Research Approach

Nowadays, the notion of PSS is often discussed in relation to the so-called Fourth Industrial Revolution (FIR) [1] and to the transition towards cyber-physical production systems [2], where systems of collaborating computational entities, connected with the surrounding physical world and its ongoing processes, provide and use data-accessing and processing services available on the internet. The relationship between Information and Communication Technologies (ICT) and PSS is seen by many researchers and practitioners as interdependent or symbiotic [3]. The data collected by intelligent devices are used in PSS design to develop and populate decision-making models [4, 5].

Yet, many companies have been observed to struggle when it comes to capitalizing on such a ‘data opportunity’ for value co-creation. A survey from Valencia Cardona et al. [6] shows how one of the most significant challenges for manufacturing firms is to clearly define the value proposition of the Smart PSS. While consumers may perceive the load of data and information generated as irrelevant, the design team may also struggle to derive useful information and knowledge from the data being collected.

The discussion on value co-creation in PSS design is mostly focused today on the development of service-centric design methods that focus on customer value co-creation [7, 8], the design of the underlying value creation proposition and architecture [9, 10], and frameworks to support the collaboration process between the customer and the provider during the entire PSS development [11].

The purpose of this paper is to shift the focus of the ongoing academic discussion to highlight which opportunities and challenges are perceived by industrial companies when boosting value co-creation in PSS design through data-driven approaches. The research question at the center of this work is described as:

What challenges and opportunities are differently servitized companies seeing in value co-creation and operational data utilization?

The findings presented in this paper emerge from a multiple-case study conducted in collaboration with three industrial partners in Sweden that feature different levels of maturity in their servitization journey. These case companies were selected through a logic of literal replication, to find similar results in different contexts and provide compelling arguments for the findings presented in the following sections. Semi-structured interviews were conducted at the case companies to gather information and perspectives on value co-creation. The questions were prepared beforehand and focused mainly on value co-creation, servitization, and data utilization. The findings from the studies presented in this contribution have the goal to spotlight common themes among the firms when it comes to value co-creation and data utilization in design. Additionally, reflections on how to meet and solve these are concluding this paper.

2 Theoretical Framework

2.1 About Value and Value Co-creation

A common definition for ‘value’ is hard to agree upon. An early attempt to capture its meaning can be found in Miles [12], who describes it simply as the ratio between performance and cost. Later definitions have had the objective to pinpoint with more granularity the nature of the ‘value’ concept. Among them, the European Committee for Standardization defined it as ‘satisfaction of needs in comparison to expenses’ [13].

In turn, a need describes ‘what’ a solution shall do to solve a problem or fulfill a wish of a customer [14]. The latter is often referred to as Voice of the Customer (VoC). To add more complexity, a need is not necessarily one-dimensional, rather its degree of fulfillment and satisfaction can have multiple characteristics and change depending on the market, as in the Kano model [15]. However, evaluating and verifying something expressed naturally and informally is challenging. Hence, the needs must be translated to requirements which are the formal and verifiable statements expressed in an abstract and technologically neutral way [16].

What is value co-creation then? This paper borrows the definition by Ranjan and Read [17] which states that value is co-created when a customer actively collaborates with the provider, directly or indirectly, through one or more stages of production and consumption, referred to as co-production and value-in-use. From a co-production standpoint, value co-creation can practically take part as a co-joint effort between provider and customer in eliciting requirements and ensuring that the design can interpret and fulfill these. On the other hand, value-in-use reflects the more servitized aspect of a PSS and mitigates collaboration during the service deployment. Ultimately, value co-creation can be seen as a natural part for servitized firms and a good path for enhancing value delivery throughout the life cycle.

2.2 Value Co-creation in PSS Design

PSS stresses the importance of designing products and services that manage to fulfill customers' needs beyond the functional perspective and thus can value co-creation serve as a good approach for achieving this. From a conceptual standpoint, the need for value co-creation throughout the operational phase means that the requirements of the system will change during the life cycle, and thus there is an inherent need for including changeability in the design of a PSS. Recent research highlights how value co-creation is one of the major challenges which PSS faces, e.g. in the words of West et al. [18]:

“The smartness of a product-service offering is not linked to how many new technologies are exploited. Instead, it depends on the extent it actively enables new forms of value co-creation.”

While in traditional one-sale models the customers are passively involved in the process of value creation, the servitized solution leverages the importance of co-creative value by emphasizing aspects such as interaction and personalized customer experience [18]. Liu et al. [19] provide a good example and framework of the value co-creation process for Smart PSS.

Bertoni et al. [20] bring forward Value-Driven Design (VDD) for PSS as a modeling methodology to keep track of the co-creation of value during the design process. Instead of a strategy that aims at fulfilling and maximizing each requirement individually, VDD adopts a higher-level optimization strategy where the requirements are combined to a unified conformity. A major issue with value modeling today is related to the need to incorporate data streams from the operational stages of the product/service to enable better decisions that are more grounded on the actual behavior of a solution along its life cycle.

3 The Case Companies

As previously mentioned, this paper is a result of interviews made at three different case companies and their perspectives on PSS value co-creation and operational data. Following is a short description of each of them.

Company A is a traditional manufacturing firm that has a clear focus on delivering products to its customers. They operate in the infrastructure equipment sector and have a worldwide market base where they provide vehicles for road construction. Onward, the firm offers services directly connected to the reliability and maintenance of the machines. However, in recent years they have started a servitization journey and have investigated the opportunities of offering more PSS solutions by expanding the service portfolio. The value is mainly oriented around the functional aspects and non-functional properties are mostly limited to a “must-have”-basis. At the same time, telemetry is implemented to allow real-time data collection and the ability to track their machines in their operational context. Today, a plethora of data is continuously collected and stored but the utilization is still rather low. The collected information is almost exclusively used during the operational phase and connected to maintenance and management by

the customers. So far, the data is not used during the design phase and conceptual development to any significant extent.

Company B is active in the facility sector and supplies solutions for a variety of contexts related to the movement of people. They are, in comparison to the first case company, more invested in services and see it as a vital part of their business portfolio, which accounts for a substantial part of their revenues. They are a well-established enterprise with customers spread across the world. On the other hand, they are not so far ahead in the operational data domain. Using data collection strategies during the operational phase is not a common practice in their sector and market niche, despite their products and solutions being complex and involving a plethora of components.

The final case company, Company C, is a start-up in the logistics and transportation market. The firm is only a few years old and has a high focus on technology and data utilization in its PSS solutions. The business strategy is here more result-oriented PSS where the physical hardware is not necessary as important as the services and the connected technologies. Company C is more mature than A and B when it comes to utilizing operational data in design. The operational data is a natural part of the design process, their system architecture, and the life cycle. They have additionally seen the potential and to a large extent deployed data capitalization as a part of their result-oriented PSS business.

Concluding, the case companies' characteristics and positioning on value co-creation and data utilization are summarized in Table 1. Firstly, the degree of servitization can be viewed using the stages of PSS business models defined by [21]. Secondly, the degree of value co-creation and data utilization is qualitatively estimated from low to high where low refers to no or insignificant relation to value co-creation or data utilization and high refers to a well-established process and culture of value co-creation or leveraging data. The data utilization is further divided in a customer and provider perspective.

Table 1. The case companies

	PSS orientation	Data utilization Customer	Data utilization Provider
Company A	Product-oriented	Medium	Low
Company B	Use-oriented	Low	Low
Company C	Result-oriented	High	High

4 Descriptive Study Findings

The multiple case study and interview series resulted in five interviews lasting for about one hour each. The transcripts were refined, and valuable information was extracted from a case database. Despite that the three case companies are rather different, they are to a large extent sharing the same set of challenges and opportunities when it comes to value co-creation and data utilization which can be summarized as follows.

4.1 Educating the Customer

Understanding the customers' behavior is fundamental for delivering a 'good design', and a data-driven design process is seen to provide exactly the context-specific customer information that designers need for decision-making. Company C showed a good example of this when describing how it managed to fully incorporate field data in the design process to faster build knowledge about the operational scenario while reducing shrinking the lead time for prototyping. Even if not all companies were found to be as mature on this matter, they shared the same view with regard to the potential of data-driven design.

Data helps us better understand how the products are actually used. It gives us room for more evidence-based decision-making.

Product Owner, Company B

At the same time, all the companies were aware of how a data-driven approach can reduce biases in the definition of needs and requirements for design solutions.

Quantitative methods are important for validating qualitative input. Without it, there is a risk of only hearing the loudest customer.

Product Owner, Company B

However, they also concluded that the market in general – and their customers in particular - have not yet fully grasped the potential of data-driven design to boost value co-creation. This issue was found not to depend on the degree of servitization reached by each company. On the contrary, they all expressed difficulties when it comes to educating the customers in recognizing the potential of data utilization, and they all provided examples of 'hesitant' customers, not yet ready to jump on board.

It is hard for the customer to understand, and it requires that they rethink how they run their operations.

Vice President Product, Company C

A closer look shows that sometimes the PSS providers themselves do not fully understand how to capitalize on the data being shared, thus struggling to develop a convincing selling point and convey the message onward. What is lacking is a pot of good examples that can be used to convey the benefits linked to data sharing.

The customers are not ready and do not fully understand the benefits of collecting and leveraging operational data for servitization. But neither do we fully grasp it.

Product Owner, Company B

Moreover, value co-creation can sometimes be difficult to argue for in general. The infrastructure company experienced difficulties in moving the discussion away from performance and cost. They felt that they did not know how to raise more holistic aspects toward a total cost of ownership and life-cycle view.

It is very hard to get the customer to move away from purchasing costs, they tend to focus on performance and price solely.

Product Family Owner, Company A

Company B and C, which both have a more service-balanced portfolio, found it easier to address these holistic perspectives and to argue for value co-creation.

4.2 Filtering Out the Noise

In PSS design, data can be generated by several sources along the entire solution life cycle. While some literature emphasizes the topics of data ‘democratization’ and accessibility as the main hurdle for PSS providers, companies A and B have pointed to a different issue. A major concern for them is that of motivating internally why certain types of data are even worth being collected, which is that of providing arguments and evidence on how different data types can generate value in the design process.

We collect a lot of data today, but we do not know how to use it and why these specific data sets are actually collected.

Product Manager, Company A

Several interviews pointed to the need of defining a consistent data collection strategy, battling with the issue of how to filter out the ‘noise’ from the available data sets. Even if Company A and C were found to have the most established operational data collection procedures, they showed concerns when it comes to having the full picture of what ‘data’ are needed to create value-adding solutions.

There are many asking for data, but few can go further in-depth and say exactly what kind of data they want.

Product Owner, Company B

The companies in the study further highlighted the main value-added of a data-driven approach being that of providing evidence about how PSS solutions are de-facto operated in the field depending on the context, as opposed to relying on anecdotal or personal evidence.

We do not fully understand how our products are operating in different contexts in comparison to how they were developed.

R&D Manager, Company A

This issue is emphasized when operating in global markets, mainly because the application of more classical need finding methods (interviews, observations, and more) becomes a behemoth task for PSS providers. In practice, only a data-driven approach is seen to affordably provide information on how PSS are working in different contexts in the global arena.

4.3 Thinking Ahead

Noticeably, the implementation of (late) changes in the PSS hardware is acknowledged to be a labor-intensive process. The deadline for completing the physical design is often quite long before the start of production as the tools, supply chain, and production requires long lead times.

Most of the design is fixed up to a year before the start of production.

Project Manager, Company A

The study shows that it is significantly more time- and resource-consuming to implement a design change on the product component of the PSS compared to its software side. Furthermore, a design iteration normally takes longer for the physical hardware, and this makes engineers scratch their heads when trying to balance the two development processes.

A software change can be done in a night but any change to the hardware requires coordination between multiple stakeholders and take much longer.

Vice President Product, Company C

The need to develop (and test) one or more physical prototypes is a clear example of the misalignment between the hardware and software design cycles. A way-out strategy for engineering designers is often to emphasize the changeability and upgradeability of the physical product, to make room for later changes without requiring significant rework. In practice, while the service component of a solution might change during the PSS life cycle, the product is designed from day one to be able to accommodate such changes.

5 Concluding Remarks

Regardless of the industry, degree of servitization, and size of the company, there are challenges and hurdles when working with value co-creation and data utilization. There is a difficulty in collecting the “right” data as well as knowing how to leverage this for both direct value co-creation in terms of service offerings but also indirect through design improvements.

A first acknowledgment from the study is that there is a correlation between the degree of servitization and the extent of value co-creation, value-in-use. Hence, aiming for higher servitization and a more service-dense business model can be a natural strategy for increasing value co-creation. Both Company A and B expressed that they see servitization as an opportunity to increase the value of their system by offering a higher value-in-use. Company C shared this view but has come further in the implementation and actively operated with a strong value-in-use focus. However, it is important to ensure competencies in service development if it is desired to grow in this domain. This could be achieved by either accumulating the competencies or by setting up partnerships with service providers.

Looking at the co-production perspective, Company C exhibited a large maturity for co-production stemming from a strategic decision to maximize the customer’s input

throughout the design process. Company A found it challenging to navigate among the customers' voices and saw a risk of sub-optimization when only listening to a few. Company B had similar worries that the more diverse the product portfolio and market becomes the harder it gets to find the "sweet spots" of customer input. All companies experienced challenges with getting the customers on board in co-production and getting them involved actively in the design process. Identifying customers that represent most of the market for co-production partnerships could be a good initial step to start exploring this domain more systematically. Value co-creation requires a commitment from both the customer and the provider.

All companies expressed an opportunity in how operational data can be used as leverage for value co-creation. From a co-production perspective the operational data, which is a combination of user-generated and context-dependent, enables the provider to tap directly into the customer's interaction with the system. However, collecting and extracting insight from operational data only provides a part of the picture. For this to be useful, it needs to be connected to the customer experience. Kim and Hong [22] elaborate on this when they derived a method for developing personalized services based on customer experience and contextual data. This shows that value co-creation requires collaboration between ethnographic and data-driven approaches. Simply connecting the requirements' metrics to sensory data is one example.

One way to utilize data for value co-creation in the design process is by quantifying the system value and deriving measurements based on available data. The companies will then be able to assess the value delivery of a system and evaluate how different concepts perform more objectively, as is the aim of VDD. By better understanding how different parameters influence value, it is possible to perform value optimizations and concept evaluations in more detail or even assess the value delivery in real-time. Therefore, it is recommended that the companies investigate how the requirement fulfillment can be expressed using available data.

The operational data can further be used directly for creating value-in-use concluding that data utilization has the potential to increase the value co-creation in both dimensions. However, the challenge experienced was identifying which data is valuable to collect and share. None of the companies had an explicit data collection strategy, even though Company C had one implicitly, and a clear understanding of how to use data for creating value co-creation. A workshop or discussion about identifying good data collection strategies could add great value for achieving a higher utilization of data and increasing the value of the data itself. In general, the emergence of data provides good potential for value co-creation, if the company can understand the "what" and "how".

6 Future Directions

Based on the multiple-case study, a few wishes for future research could be found. Firstly, there is a need to develop support for how a servitized company can work with value co-creation and more efficiently transfer it into the PSS design. Secondly, operational data has a great potential for supporting value co-creation, but their inter-relationship is still unclear and how it can be implemented in Smart PSS. Support for navigating between value and data is required. Finally, the result in this study remains at a holistic

level and more in-depth case studies would be useful to go further in the challenges and opportunities for PSS-oriented businesses when it comes to value co-creation and data utilization.

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