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Implementing sustainable product–service systems utilizing business model activities

Wiebke Reim[a]*, Sambit Lenka[a], Johan Frishammar[a], Vinit Parida[a,b]

[a]*Entrepreneurship and Innovation, Luleå University of Technology, Luleå, 97187, Sweden*
[b]*Department of Management, University of Vaasa, Vaasa, 65200, Finland*
* Corresponding author. Tel.: +46-920-492079;. *E-mail address:* wiebke.reim@ltu.se

Abstract

To stay competitive and comply with government legislation, many global manufacturing companies try to diminish their environmental impact and avoid commoditization of their products by offering sustainable product–service systems (PSS). Offering PSS successfully is highly challenging, however, and significant interfirm heterogeneity exists with regard to successful PSS provision. Based on multiple case studies in two global manufacturing companies, the importance of the business model as an organizing device to align and coordinate key activities and scarce resources in PSS is highlight. The analysis provides insights into the underlying building blocks that will help firms implement a PSS business model and provides new implications for analyzing and improving PSS offers.

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Keywords: Product-Service Systems (PSS); Business Models; Sustainability; Servitization

1. Introduction

Many global manufacturing companies seek to reduce their environmental footprint, because governmental policies and legislation are striving to diminish environmental impact. In addition, many customers demand cleaner and more environmental-friendly products and production [1]. A promising—but challenging—way to achieve sustainability while also fulfilling customers' needs and ensuring firm profitability objectives is to combine products and services into a sustainable product–service system (PSS). This entails providing an integrated mix of products and services that fulfill certain customer needs in an economical and sustainable manner [2,3].

Offering sustainable PSS is inherently challenging. These challenges are related to the design and sale of product-service combinations, aligning interest of all stakeholders, required changed in the mindset of all actors and the prevention of rebound effects and less carful customer behavior [3,4,5,6]. Consequently, many firms struggle to develop and deliver PSS effectively to contribute to the triple bottom line of environmental, economic, and social payoffs [7,8].

Recent studies have contributed with valuable insights into addressing the specific challenges manufacturing firms face for successful PSS provision [e.g., 9,10]. These studies reveal a rather fragmented and isolated perspective on how to effectively offer PSS to customers. Studies tend to focus only on certain tools that can help address very specific problems [1,11]. Indeed, important questions pertaining to the overall firm's logic of how value is created, delivered, and captured have remained unanswered even though such issues are critical to providing PSS successfully [4].

In response to this lacuna, some researchers have proposed that a business model perspective [12] could provide a better understanding of how to approach successful PSS provision [8,13]. Commonly, the business model concept is used to illustrate a specific offer emphasizing the differences between PSS and a traditional, product-based business model [14] or to showcase the relevance of external networks in the business model implementation process [5]. Although many of these recent studies have tried to convey the utility of the business model concept in PSS provision, none provide an inclusive view of business models that considers the underlying

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building blocks and activities that are needed to implement PSS [9,15].

To address this gap, the purpose of the present study is to provide insights on the underlying foundation of how manufacturing firms benefit from applying and using the business model concept for providing sustainable PSS. More specifically, in the present study the focus is on identifying and describing the building blocks and the activities that are necessary for PSS business model provision. The study also shed light on how firms organize these activities such that they overcome challenges and make their PSS business models work. The analysis is grounded in case studies of two global industrial manufacturing firms that offer sustainable PSS to their global customer base. The present study provides empirical insights into which activities are necessary for manufacturing firms to undertake to effectively create, deliver, and capture value by providing PSS. In sum, the present study provides novel insights and contributes to the emerging discussion regarding the relevance of the business model concept in adopting and providing PSS.

2. Theoretical background

2.1. The emergence of the sustainable PSS concept

Initial studies on PSS recognized the sustainability and environmental implications were fundamental, and the PSS concept was defined around these aims [7,16]. Over the years, however, sustainability was treated more as an inherited result of PSS, and the focus shifted to achieving economic benefits and customer satisfaction [17]. In hindsight, several studies have acknowledged that in certain cases PSS results in a negative effect on the environment through less careful behavior and rebound effects [3,6]. In recent years, however, the emphasis has shifted to achieving sustainable benefits by recognizing the need to work actively to realize the full sustainability potential of PSS [1]. Sustainability in PSS can be reached mainly through improved resource utilization or innovations that change operations such that they are more beneficial for the environment [8]. By producing fewer products and increasing durability and recyclability, the PSS is optimized to be eco-efficient [14,18]. Thus, by focusing on the entire life cycle, reducing the environmental impact of PSS is a strong argument in the literature [1]. With these thoughts at the forefront, Vezzoli et al. [19] established PSS as a sustainable concept, where the economic and competitive interests of the providers continuously seek new solutions to environmental, social, and economic benefits.

Additionally, many researchers have pointed out that the challenges firms face when implementing PSS often negatively affect the firms' performance [20]. To address these challenges, some researchers have proposed that constructing a well-structured business model perspective could contribute to a more inclusive approach to PSS provision [8,13,15]. Furthermore, such an approach could potentially contribute to improved performance, especially in firms that implement advanced, results-oriented PSS.

2.2. PSS business models: Components and challenges

Teece [12] defined business models to center on how value is created, delivered, and captured. The literature lacks clarity, however, surrounding the single components of this definition, and it seems open for interpretation as to exactly what activities these components entail. The initial literature on the PSS business model concept has commonly been used to categorize different types of PSS such as product-, use-, or results-oriented [3,18]. More recent PSS studies have highlighted that business models are central to implementing PSS successfully [8].

Many prior studies on PSS business models have focused on transitioning from providing products to solutions and on network aspects concerning PSS [e.g., 5,9]. Other studies on PSS business models have mainly developed frameworks that focus on specific elements that are part of PSS business models [4]. However, the lack of an explicit definition of the three business model components (value creation, value delivery, value capture) hinders applying this concept to sustainable PSS. Nevertheless, the literature frequently touches on different aspects that constitute the business model components, as well as challenges. On the one hand, value in sustainable PSS is created by taking over work tasks from customers and accomplishing them more efficiently, which also improves the relationship with the customer and their loyalty [1,18]. On the other hand, value is created through positive effects on the environment in terms of reduced material use and higher levels of resource utilization [3,7,19]. Customers' knowledge and knowledge about customers are strong barriers to value creation in sustainable PSS. For example, customers that do not favor ownerless consumption constitutes a frequently mentioned barrier to successful PSS [7,17]. Value delivery is characterized by the high skill, competence, and experience levels required to control the entire process of providing sustainable PSS [8,18]. In addition, new organizational structures and new partners need to be integrated into PSS provision. Given these parameters, challenges occur because processes need to be developed, industrialized, and automated; the staff needs to be qualified; and stakeholders need to be identified and integrated into a PSS-oriented organization [18].

To capture value, it is important to design sustainable PSS such that customers are willing to pay for the added value [7]. At the same time, costs need to be handled efficiently. In addition, the profitability of PSS is difficult to show because cash flows are uncertain and quantifying savings is difficult [20]. Pricing and absorbing risks are significant problems that manufacturers need to address when capturing value from sustainable PSS [10,17]. As such, significant opportunity exists to use the business models concept to align functions and activities in the firm toward a common strategic goal, to use the concept as a coordination device, and to reach internal and external fit in the transition toward providing PSS that could positively affect the firms' performance [5]. Thus, the possibilities to exploit the full potential of sustainable PSS increase significantly, and the economic, social, and environmental benefits can be captured fully.

3. Research method

Because the phenomenon that is studied is highly complex, a multiple case study approach was used [21]. First a literature review on sustainable PSS and business models was performed to conceptually frame how PSS implementation and business models are related and can be integrated. Then two large global manufacturing companies from diverse industries that had introduced sustainable PSS into the marketplace were selected as cases for this study. Firm 1 is a heavy machinery manufacture with more than 13,000 employees in more than 120 countries. Firm 2 is a large provider of telecommunication infrastructure with more than 116,000 employees in more than 180 countries.

During the initial interaction with the case firms, it was evident they had faced numerous challenges while introducing PSS offerings. As these companies continued to expand their PSS portfolio and increased revenue through these offerings, it is expected to uncover real-world examples of how they had achieved the difficult task of offering PSS to their global customers. More important, the continued evolution of sustainable PSS offerings within the case firms provided a unique opportunity to study the construction or building blocks of PSS business models. When interacting with the case firms, the concentration was on the more advanced PSS offerings, that is, the use-oriented or results-oriented [3] offerings. For example, Firm 1 has been offering availability based contracts of their construction equipment in global markets. This resulted in having to ensure that the equipment being offered was functioning to an agreed upon level. The equipment downtime, therefore, has to be minimum, with the firm taking various pre-emptive measures. Otherwise, Firm 1 would have to use additional equipment to deliver the promised levels of availability to their customers. Comparably, Firm 2 offers a life-cycle management of telecommunication network infrastructure and functionality for its customers. With this offer they relieve their customers from the hassles of operations, migration and upgrading of their service communication delivery network.

The data collection was completed primarily through semi-structured interviews. 22 interviews (13 interviews with Firm 1 and 9 interviews with Firm 2) have been conducted through a mixture of face-to-face interviews, as well as over the phone. Each interview averaged about an hour. The interview respondents were identified from within each firm to represent the diverse functional units that were engaged directly in providing sustainable PSS. Respondents were also chosen to provide views from the strategic level and operational level, because providing PSS involves both.

The data was analyzed thematically by first organizing the interview data based on the terms, labels, and phrases into codes. This was done across multiple respondents to detect conceptual patterns that were similar in their essence. To ensure rigor and increase confidence in the analysis, multiple members of the research group developed the coding scheme independently. In the event of disagreements, the researchers discussed and modified the coding scheme until consensus was reached. This provided an independent perspective on the trustworthiness of the coding schemes [22]. The codes were combined into first-order categories, which described the key events and activities that occurred when developing and delivering sustainable PSS. Next, the authors looked for patterns and relationships within these first-order codes that could be further collapsed into theoretically distinct groupings or second-order themes. The business model dimensions of value creation, value delivery, and value capture acted as sensitizing concepts, as Blumer [23] suggested, and provided us with direction when looking for patterns in the data. These sensitizing concepts thus acted as an interpretative device, which helped inform the overall research question of this study, that is, revealing the detailed underlying building blocks and activities that are necessary for implementing PSS business models. In practice, this meant that a lists of quotes and other examples related to providing PSS in the case firms was created, which were then analyzed thematically and guided by the sensitizing concepts to help identify patterns and themes. In the following section the resulting second order activities are explained in detail based on which sensitizing concept they belong to.

4. Findings

Based on the interview analysis, a total of seven underlying activity themes related to the PSS business model were identified. These activity themes corresponded to the overall dimensions of the firm's creation, delivery, or capture of value in providing sustainable PSS. In this section, the findings from this case study which are organized under each of the sensitizing concepts that correspond to the activity dimensions of a PSS business model will be described in detail.

4.1. Value creation

A key activity in providing PSS that has been observed was **taking over responsibilities that customers previously handled**. One approach to this is *providing complete lifecycle solutions to customers*. This entails providers taking care of the solution from installation throughout its entire life period. In doing so, customers are relieved of the responsibility of maintaining and servicing the offering.

Another way that was found in the case firms on how taking over responsibilities from customers was by *taking over operational activities from customers*. This enables the PSS providers to take control of the solution and minimize risks during operations. It allows customers to employ appropriate personnel, manage product operations, and enjoy the PSS results, thereby allowing suppliers to create value.

Managing resources while providing PSS is of critical importance for suppliers, because the risk of ownership and operational costs rest on them. **Resource utilization**, therefore, becomes key to reaping benefits and creating value through efficient PSS provision. In the case firms, many ways in which improved resource utilization provided opportunities for creating value have been observed. First, it was found that *increased asset utilization* was a key factor for providing sustainable PSS. In providing solutions, the supplier firms are responsible for the output; therefore, the products or physical assets need not necessarily be stationed at one specific client's operational area. The supplier firm can then transport and orchestrate the maximum utilization of an asset across many

customers. Additionally, it was observed that the life of the individual assets was prolonged through effective maintenance and upgrades. These activities helped increase asset utilization and thereby provided opportunities to contribute toward sustainable PSS provision. Another way in which the case firms achieved improved resources utilization was by *streamlining their make or buy decisions*. Providing sustainable PSS is complex, and often firms do not have the capabilities or resources to provide all parts of PSS. In these cases, the firms must be able to decide which things to internalize and which to outsource to others. Resources are wasted when tasks or operations could be completed more efficiently by others that are better equipped to do so. Another very important factor in improving resource utilization is *minimizing downtime of the product*. Maximizing product availability ensures meeting productivity norms and, in many cases, helps exceed them. Product downtime involves additional use of materials for repair, increases in service costs, as well as investing additional capital to provide a replacement product until the product is operating again. *Remanufacturing and recycling products* is another strategy that enables supplier firms to reduce material use, thereby improving the use of resources. Because the ownership of physical assets resides with supplier companies, recycling or reuse after reconditioning helps with sustainability efforts.

In providing sustainable PSS, the intensity and quality of **interaction with customers** determines, to a great extent, the final benefit that accrues to the providers in the process. In the case companies, it was found many activities through which they intensified their interaction with customers. *Developing knowledge of the customer's processes* helps the firms customize functions and integrate sustainable PSS into the customers' processes effectively. The higher the supplier's knowledge of the customers' business processes, the greater the possibility of contributing positively to their operations. Another dimension of how the supplier firms operationalize customer interaction is by *developing predictive capabilities of the customers' requirements*. Providing PSS gives the supplier firms the ability to understand the nature of their customers' businesses. It also provides them with access to information about their customers' operations and strategy that was previously not accessible. In addition, it was found that through *customer involvement early in the design and development of the PSS offering*, the case firms could make the development process more efficient and effective. Additionally, the supplier firms were able to configure the functionality of the sustainable PSS offering early in the development process, which would have been costly at later stages of development or in the deployment stages. Table 1 shows an overview of all activities related to value creation and the subcategories.

4.2. Value delivery

External distribution networks often provide support services and serve as the frontline for manufacturing firms. In providing PSS, the supplier firms need to develop the abilities and overall delivery potential of the entire network to support the change, from providing individual products or services to providing integrated PSS. In the case firms, it was observed that developing external networks was an integral part of their attempt to provide sustainable PSS, especially in a global context. There were several activities that helped them achieve this objective. First, the *skill of the delivery partners needed to be enhanced* to support PSS provision. Traditionally, the delivery partners possessed technical- and product-related delivery and support skills. Service and customer interaction skills, which are critical for providing PSS, are often missing.

Table 1. PSS business model activities: value creation.

Taking over responsibility previous handled by customers	Resource utilization	Interaction with customers
➢ *providing complete lifecycle solutions to customers* ➢ *taking over operational activities from customers*	➢ *increased asset utilization* ➢ *streamlining their make or buy decisions* ➢ *minimizing downtime of the product* ➢ *Remanufacturing and recycling products*	➢ *Developing knowledge of the customer's processes* ➢ *developing predictive capabilities of the customers' requirement* ➢ *customer involvement early in the design and development of the PSS offering*

Second, *forging new delivery partnerships* is important in delivering sustainable PSS, because some of the key competences and know-how are completely missing in the present distribution network. The new partners help provide the missing know-how as well as the supporting eco-system to support delivering sustainable PSS from deployment until the end of the life cycle. As such, the supplier companies are well advised to have a long-term contextual view of the emerging trends in their market before finalizing their partners.

Apart from the above activities, *localization of support services* is critical in value delivery, because constant monitoring and support of the installed asset and customer interaction are required. Traditional centralized support operations often resulted in longer response times and therefore downtime losses for the supplier firms. Proximity of personnel and the availability of spare parts or other solutions-related components are critical in the efforts to localize. Finally, *developing digital interface/platforms* to manage and control the diverse distribution and supplier network plays a vital role in providing sustainable PSS. Digital interfaces have interpretative and screening abilities, which ensure that only correct inputs from divergent input sources are applied to the installed base. They can report and screen out any faults, thereby preventing any unwanted failure or damage to the installed base.

The manufacturing firms have established routines, that is, sequences of coordinated actions and skills that help them deliver products and services to their customers. With the change in focus to PSS, the supplier firms need to develop **new internal routines** that help them build capabilities to deploy PSS to their customers. In the case firms, several new routines for sustainable PSS provision have been observed. One of the important routines they had to develop was *orchestration of skills across business units*. Traditional product delivery requires skills that are already organized into functional business units. With providing PSS, however, combining and coordinating skills across the product, services, support, and customer interfacing units is required; indeed, they all need to work together.

Another new routine needed for effective value delivery in

PSS provision was *cross regional interactions,* that is, interaction between the front-end and back-end of the supplier firms. As customer interactions and support and delivery become crucial, especially in global sustainable PSS provision, the regional units that are close to the customer need to perform diverse and critical tasks to ensure value delivery in PSS. In PSS delivery, the regional units take over new responsibilities and participate in activities that were traditionally performed by central units.

Combining various elements into an integrated whole makes PSS provision a complex task. Existing systems and structures were often geared toward breaking down the overall value delivery process into simpler, more manageable parts. Therefore, in sustainable PSS delivery, the provider firms need to develop routines that can help them in *managing the complexity of PSS provision*. In PSS, however, the whole process cannot be completely broken down into simpler parts, because PSS must be provided as an integrated whole. In the case firms, it was observed that the various components of the PSS were designed to work closely with each other, while not needing to be completely integrated from the beginning. Table 2 shows an overview of all activities related to value delivery and the subcategories.

Table 2. PSS business model activities: value delivery.

External distribution networks	New internal routines
➢ *skill of the delivery partners needed to be enhanced*	➢ *orchestration of skills across business units*
➢ *forging new delivery partnerships*	➢ *cross regional interactions*
➢ *localization of support services*	➢ *managing the complexity of PSS provision*
➢ *developing digital interface/platforms*	

4.3. Value capture

Providing sustainable PSS entails increased risks, because the supplier firm engages in relational interactions over long time periods, incorporates new operational responsibilities, and promises to deliver results- or use-oriented benefits. Systematically managing the identified risks largely dictates how successful a firm is in providing sustainable PSS. In the case firms, various activities that helped the firms identify and **manage the risks** assumed while providing PSS have been found. The supplier firms face the *risk of adverse market selection* of their PSS offerings, that is, among a portfolio of PSS offerings, customers choose only PSS for equipment where the probability of asset failure is high. The reason for this is that the benefits from the PSS offer are relatively higher in the situation of asset failure compared to a situation with no failure where the PSS could be seen as unnecessary. This problem is caused through asymmetric information.

In such cases, the supplier firms try to adjust the pricing of these offerings to ensure coverage of the risk or transfer the risk to another party, including distribution partners or external third-party insuring entities. *Managing the operational risks effectively* also helps the supplier firms protect themselves from the downsides of PSS provision. With the onus of the operations now being on the supplier firms, the firms must bear the risks of technical failure and adverse customer behavior. While the risks of technical failure are mitigated through preventive and proactive maintenance, adverse customer behavior risks, such as overusing or being careless with assets, are often covered through risk-sharing contracts with customers.

In manufacturing firms, the traditional models based on the exchange value of products and services is the most common way to accrue revenue. In providing PSS, there are challenges in visualizing the benefit delivered, as well as estimating the risks involved. Therefore, the supplier firms need to structure **new revenue models** to capture the use-value generated in the PSS context. In the case firms, several new revenue models that were structured to overcome these challenges have been observed. One way to structure revenue models is by following a *value-based pricing model*. In ongoing engagements with customers, the change in the revenue model brings significant instability to the relationships. To keep the overall revenue mechanism similar, while still capturing the additional benefits delivered in sustainable PSS, these firms charge a premium linked to the product that captures the value of the services delivered to customers.

In other instances, where no direct product is involved but where the supplier firms promise to deliver the benefit or result, customers are reluctant to buy-in, because they are unsure how to quantify the benefit they receive. In such cases, structuring a *profit-sharing revenue model* is a win-win for both. The supplier captures the additional revenues, and the customer sees direct benefit accruing to their bottom line.

Sometimes the upfront cost of PSS becomes high due to the addition of components that are required to deliver the functional benefits that ensues from integrating products and services. Additionally, with the uncertainty of the value delivery of the PSS, customers are reluctant to make an initial commitment. In such cases, firms implement a *pay-as-you use revenue model* (monthly or a fixed time period). This helps customers adopt sustainable PSS offerings, and supplier firms can offer sustainable PSS to a wide range of customers that would not otherwise consider taking up the offerings due to high upfront investments. Table 3 shows an overview of all activities related to value creation and the subcategories.

Table 3. PSS business model activities: value capturing.

Manage risks	New revenue models
➢ *risk of adverse market selection*	➢ *value-based pricing model*
➢ *managing the operational risks effectively*	➢ *profit-sharing revenue model*
	➢ *pay-as-you use revenue model*

5. Discussion and implications

The present study addressed the need for insights regarding how traditional industrial manufacturers can effectively adopt and implement the business model concept in providing sustainable PSS so that firms can create, deliver, and capture value in a way that fulfils customer needs in an economically beneficial and sustainable manner [2]. Although the literature widely recognizes that the business model provides a perspective regarding how firms can create, deliver, and capture value [12], empirical evidence of successfully implementing the concept in an eco-efficient manner does not yet exist [4,8]. Rather, the literature commonly presents an isolated and fragmented perspective on specific challenges PSS providers face or conceptual frameworks that only focus on emergent processes and constituents in business models [8,15]. Additionally, little is understood of the building blocks and activities needed to implement a sustainable PSS business model [11,15].

The present study holds two key theoretical implications to

the PSS and business model literatures. This study contribute to the literature first by empirically showcasing the activities and initiatives that form the building blocks that manufacturing firms need to adopt successfully implement a sustainable PSS business model. This provides a unique, multilevel view of activities for implementing a sustainable PSS business model, which has not yet been proposed. As such, the present study extends the understanding of using the business model concept as an organizing framework in the context of initiating activities that are unique and necessary for successfully providing PSS that contributes to the triple bottom line [2].

In addition, initiation of the sustainable PSS concept has always had shape emphasizing sustainability benefits [7,16], and over time the focus have been extended to also explicitly include economic and customer satisfaction benefits [17, 24]. However, recent literature has questioned to what extent does offering PSS inherits focus on the sustainability aspects [1,19]. This has led to emphasis on achieving a triple bottom line but no micro-foundational understanding presently exists in the literature towards achieving such ambitious goal [11,15]. The present study contributes to this discussion by showcasing how business and strategic development activities can be organized using a business model framework to achieve this objective.

Practicing managers can take inspiration from the present study regarding how the business model concept can be used as an organizing device to effectively providing sustainable PSS in their firms. The business model activities could also be used as an evaluation tool for the on-going PSS implementation process within the firm. This could help a firm's decision makers implement policies that can help effectively coordinate and integrate processes across business functions both within firms and with external actors. Operational managers can use the present study when implementing specific activities that can facilitate the firm's overall sustainable PSS provision. Such activities can range from identifying particular activities to implementing activities, keeping in mind how they contribute to a particular dimension of the firm's activity.

In the context of this case study research, many interesting avenues for further research emerge. It would be interesting to know what other activities could contribute toward enhancing the dimension of a firm's activities in creating, delivering, and capturing value in providing sustainable PSS. Further research could extend the findings of this study in this direction. Another question of interest for future studies is to investigate how alignment of the individual activities can be enhanced to improve the firm's implementation of a sustainable PSS business model. This can be done both within the business model dimensions, as well as across them. For this kind of study to have value for decision makers, it would be interesting to see studies that explored these aspects both qualitatively and quantitatively.

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