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Research Article

Why are companies moving on towards Product-Service Systems? A framework for PSS drivers

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Abstract

Paper aims: The research aims at identifying the main drivers that motivate companies to adopt PSS towards a framework considering strategic, tactical, and operational levels.

Originality: Paper´s relevance comes from the development of a research tool that can be used by other researchers in different PSS research whether related to strategic issues or driven by low environmental impact trends. In addition, PSS drivers construct analysis.

Research method: A survey-based method, with a questionnaire with 30 questions were developed based on previous literature and applied to 85 executives, qualified to answer questions specifically related to the driven forces towards PSS, from different industries in Brazil. The survey data was analyzed by structural equation modeling.

Main findings: The results identified six main drivers: competitive advantage, portfolio, co-creation, co-production, integrated solution, and environmental sustainability. Besides, a framework looking at the integration of these six drivers is discussed in a three-level perspective strategic, tactical, and operational.

Implications for theory and practice: The paper could support organizations that are aiming at being a PSS provider by providing a better understand of the main drivers for moving towards product-service system solutions and it provides empirical support for the effects of hybrid models in manufacturing companies.

Keywords

Business drivers. PSS. Servitization. Research instrument.

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1. Introduction

Companies are continuously transforming their original business structure, shifting from manufacturing organizations to hybrid models (May et al., 2022; Vasantha et al., 2015). These transformations involve substantial investments in service-oriented approaches, driving organizations, industries, and nations towards servitization (Chang & Yen, 2012; Díaz-Garrido et al., 2018; Moro et al., 2023).

Servitization evolves around the physical product combined with a set of services (Díaz-Garrido et al., 2018; Nemoto et al., 2015) leading to product-service systems (PSS) with different focuses. The first one focuses on the strategic framework adopted by manufacturing companies (Oliva & Kallenberg, 2003) to remain competitive (Baines et al., 2020). The second aims at possible environmental benefits associated with the provision of a PSS (Vezzoli et al., 2015a; Zhang et al., 2022). The last concentrates on the customer's perspective, suggesting a closer relationship between supplier and customer (Haber & Fargnoli, 2019; Morelli, 2006; Zhang & Ming, 2022) Additionally, it aims at differentiated customer experiences offerings with this transition (Lee et al., 2015;

Zhang & Ming, 2022), which mostly depends on the design phase partnerships (Dewit, 2016; Moro et al., 2022; Schallehn et al., 2019).

This shift in paradigm is also influenced by the dynamics between customers, producers, service providers, and governments (Garbie, 2017; Pakdeechoho & Sukhotu, 2018), throughout the whole business ecosystem (Adner, 2006; Wang et al., 2023). Thus, the organization is no longer just a producer but also a service provider or even a solution provider (Wallin et al., 2015) contributing to system innovation (Iñigo & Albareda, 2016; Shleha et al., 2023).

Nevertheless, many companies suffer from the dilemma of technological innovation and servitization (Eggert et al., 2022; Kessler & Brendel, 2016) and the "service paradox", incurring higher costs with no realized returns (Gebauer et al., 2005; Kastalli & Van Looy, 2013).

In this context, companies are pressured to move towards a new paradigm, lacking a clear understanding of the drivers (Battisti et al., 2023). PSS deal with multi-functional networks to meet strategic objectives, facing different taxes and government rules, which can result in higher expenses (Benedettini et al., 2015), government incentive issues (Ceschin & Vezzoli, 2010), socio-technical transitions and regulation (Ceschin, 2013), linked to different service and asset transition stages (Baines et al., 2017; Erguido et al., 2022).

When the focus is strategic, different drivers lever companies in this transition, such as creating entry barriers, being closer to their customers, meeting the demand of their consumers, facilitating business management and control (Haber & Fargnoli, 2019; Kurpiela & Teuteberg, 2022; Martinez et al., 2010). Concerning the environmental aspect, PSS has the potential to lead towards sustainable resources consumption, providing an effective transformation of socio-cultural behavior, usage patterns (Moro et al., 2022; Santamaria et al., 2016) and circular economy (CE) through product life extension and product sharing (Bocken et al., 2017) and different levels of social engagement (Kühl et al., 2023). However, this always depends on the case and only when PSS influences the reorientation can it be called S-PSS (*Sustainable Product-Service System*) (Vasantha et al., 2015). Similar criticism is devoted to the PSS since that is no guarantee it might influence as an enabler of CE (Kjaer et al., 2019; Kühl et al., 2023). When the focus is on the customer, PSS drivers are pursuing value co-creation by catalyzing organizations, consumers and other stakeholder partnerships (Morelli, 2006).

Different drivers affect PSS design, which encompasses a set of strategic, environmental, and customer-oriented aspects pushing companies to face challenges towards PSS. However, there is a lack of evidence from empirical studies (Wallin et al., 2015), with scarce studies reporting pieces of evidence in a systematized and quantitative way (Moro et al., 2023; Sakao et al., 2009). Adding to it, clarity on empirical evidences regarding actual drivers for PSS adoption are crucial to avoid waste of resources in an eventual deservitization process (Battisti et al., 2023). Therefore, two research questions were proposed to address these gaps:

RQ1: Which are the drivers that motivate companies to adopt Product-Service Systems?

RQ2: Which drivers mostly influence the type of PSS adopted?

To address these questions, a survey-based approach with exploratory factor analysis (EFA) research was applied to 85 executives, which were already pursuing the path to become PSS providers for at least five years.

This paper is organized as follows: Section 2 presents the main drivers and theoretical foundations on product-service systems; Section 3 presents the research methods applied; Sections 4 and 5 show the results and discussion of the findings. Finally, Section 6 summarizes the conclusion of this research.

2. Theoretical background

2.1. Product and service transition

Former manufacturers have been changing their original business focus from goods to services in a progressive way. Since 2000, services have been seen no longer as an after-sales option but as a business strategy (Moro et al., 2023), moving the concept to Service Economy 3.0 (Chang et al., 2014).

When it comes to the motivation for the transition from products to services and the consequent strategic vision to compete through services, it is worth mentioning the transition logic (Lusch et al., 2007; Vargo & Lusch, 2004, 2008). For these authors, there are two logics to consider. The first is called *goods-dominant logic* (G-D), in which the purpose of economic activity is to produce things that can be sold. Here the product is the transaction focus, and services are considered a restricted product type (intangible) or a manner to increase the product value. Standard goods are produced without the customers' direct participation in order to obtain

maximum efficiency and patterning (Baines et al., 2009). In the second logic, *service-dominant logic* (S-D), the processes are based on commitment to and mutual collaboration with customers, partners and employees (Smith et al., 2014). The problem in the transition between these logics is that services fundamentally require different operations from products, since the provider needs to be closer to customers in long-term relationships that allow them to co-create value (Vargo & Lusch, 2008; Zhao, 2022).

The transition of traditional manufacturers to PSS providers, in general, is accomplished gradually (Baines et al., 2017). It starts with the identification of services as a business opportunity for operations guidance around customer needs (Martinez et al., 2010) evolving to a specific offer design (Moro et al., 2022). However, many PSS suppliers fall into the "servitization paradox" (Kastalli & Van Looy, 2013), with losses in their services business (Battisti et al., 2023) by aggregating high levels of risks and uncertainty (Kreye et al., 2013).

2.2. Drivers for the adoption of Product-Service System

According to Mont (2002), drivers can also be classified into internal and external to the company. The internal ones derive from the economic, environmental, and social advantages of adopting a servitization strategy for both PSS providers and their customers (Taticchi et al., 2015). External factors can support or delay the adoption of a servitization strategy, such as the evolution of technology maturity, changes in regulations (Ceschin, 2013; Finne et al., 2013; Kühl et al., 2023) or the economic context in a broader way (Ehie & Muogboh, 2016; Pakdeechoho & Sukhotu, 2018). Recent studies also highlight aspects regarding service offering: activeness in offering captures the firm's internal emphasis and the revenue contribution captures the customer demand for such services (Moro et al., 2022; Partanen et al., 2017) and innovative internal capabilities (Coreynen et al., 2020; Wallin et al., 2015).

To synthesize the drivers under consideration for PSS development in this study and to facilitate results analysis, they were grouped into three main approaches. The first, focusing on the strategic framework adopted by manufacturing companies (Baines et al., 2020); the second, aiming at possible environmental benefits associated with the product-service system provision (Mont, 2002; Tukker, 2015; Zhang et al., 2022); and the last, focusing on the customer's perspective by looking at the transition from product into service as a step to create differentiated customer experiences (Santamaria et al., 2016; Zhao, 2022).

2.3. Strategic intent in Product-Service System

For companies, service adds are changing the competitive dynamics in a problematic transition process (Johnson & Mena, 2008). This process creates essential challenges to these companies, which may require increased investment, changes in risk profiles, or even breaking the paradigm that providing services is beyond their competences (Battisti et al., 2023; Kreye et al., 2013; Martinez et al., 2010). Restructuring takes place at various levels within the organization, and new metrics and incentives are made necessary. The business emphasis moves from selling a product to a complex relationship with the customer, which Baines et al. (2009) named servitization strategy focused on the product.

The Product-Service System (PSS) is also known as a *function-oriented business model* (Van Ostaeyen et al., 2013). PSS emerged as a range of new approaches and market trends beyond simple product and service aggregations and is often associated with the change in ownership and structure of a company (Smith et al., 2014). Some of the changes worth mentioning are: the sale of the product use, rather than the product itself (Matthyssens & Vandenbempt, 2010); the replacement of goods by "service machines" (Van Ostaeyen et al., 2013); the transition from a disposal society to a recovery society (Cook, 2014); and changing consumer attitudes, owing to the change in the process from a simple sale to a complex service guidance (Santamaria et al., 2016). Each of these new trends requires effort and presents limitations and restrictions when employed separately (Baines et al., 2009; Martinez et al., 2010). However, when combined, they make up a complete system solution for the customer (Pereira et al., 2016). At this point, knowing the differences between services and products is no longer relevant, since both are provided as a single intrinsic system (Gao et al., 2011). According to Mont (2002), this aggregation aims to facilitate the transition of consumption and production systems into a single system in which products, services, supporting infrastructure and networks are designed to provide a unique and complete package to the consumer and, at the same time, have the potential to minimize environmental impacts by changing consumption patterns. For Morelli (2006), PSS has specific characteristics that arise when comparing its characteristics component, product and service. Examples are the relationship between users, designers, and service providers; time of production and consumption; material intensity; implications for designers; and designing PSS.

The term PSS has many definitions, even though many are similar (Moro et al., 2023). In general terms, as previously mentioned, PSS defines an inseparable integration of products and services (Kuo & Wang, 2012), although

the ownership and control issues pose significant challenges to the concept. Park et al. (2012) proposed the term "integrated product–service" (IPS), as a major umbrella for this integration, regardless its type, objectives, and features. Thus, this study suggests the following operational definition: *PSS is a system of products, services, and interactions to provide a product-service solution to meet customer (shareholders' and users') needs sustainably.*

2.4. Environmental influence on Product-Service System

Some authors distinguish PSS from servitization based on issues concerning "dematerialization", focusing on the use of goods rather than on ownership (Mont, 2002; Park et al., 2012), even though little attention is given to this concept at political and operational levels (Baines et al., 2017; Kühl et al., 2023). However, its association with sustainability is supported by several authors, such as Goedkoop et al. (1999), Roy (2000), Liedtke et al. (2013), Gelbmann and Hammerl (2015), Vezzoli et al. (2015b), Pigosso & McAloone (2016). For them, PSS has the potential to lead to sustainable resources use to an effective socio-cultural behavior transformation and usage patterns (Zhang et al., 2022). In other words, PSS frequently focuses on sustainability depending on the contingent factors (Kühl et al., 2023) as evidenced by Manzini & Vezzoli (2003) and by Vasantha et al. (2015).

Considering the *triple bottom line* from Elkington (1999), PSS may be termed S-PSS, *Sustainable Product-Service System* (Maxwell et al., 2006), only when it helps to guide trends and unsustainable consumption practices in the economic, social and environmental spheres together. Consequently, the concept of dematerialization arises, which is the opportunity offered by PSS to detach the idea that the value delivered to the customer is directly linked to the amount of physical material required to generate this value (Vezzoli et al., 2015b). The term also refers to a reduction in material flows in production and consumption and to creating products and services that offer customers the same level of performance, with a lower environmental burden (Abdul-Rashid et al., 2017). Also, according to Mont (2002), the main PSS goal should be to reduce the environmental impact of consumption by closing the materials cycle. Adding to it the dematerialization of PSS would evolve with the continuous provision of systems based on the integration of elements along the offer lifecycle with improved features and functional efficiency of each component (Pacheco et al., 2022; Wahyudi et al., 2022).

2.5. Customer role in Product-Service System

Customers have largely driven servitization. According to Sakao et al. (2017), the customer is seen as the main focus of PSS. The objective is to offer a complete solution to the customer (Iñigo & Albareda, 2016), aiming at the result rather than just the product. As pointed out by Vandermerwe and Rada in the 1980s and more recent studies, customers demand more services (Dmitrijeva et al., 2022).

Nevertheless, this does not mean that they want fewer products but that they want services that may assist them in making the right decisions. In general, they intend to acquire the product when and where they wish, using it to its maximum capacity and knowing what to do when things do not work out (Lee et al., 2015). The customer becomes a collaborative partner involved in value creation and capable of acting over other resources (Van Ostaeyen et al., 2013; Wahyudi et al., 2022). The idea is to cultivate relationships involving customers for customized development, creating competitive and attractive value propositions to match specific needs (Haber & Fargnoli, 2017, 2019; Moro et al., 2022; Vargo & Lusch, 2004). Thus, the market strategy turns from "oriented" to the client (goods-dominant logic) to be "centered" on the client (service-dominant logic) (Dmitrijeva et al., 2020; Lee et al., 2015).

To reach a satisfactory level of customer experience, accurately implementing service business models requires understanding consumers with R&D intensity and strategic partnerships based on technical development and customer engagement with implications on performance (Bustinza et al., 2019; Dmitrijeva et al., 2022). Thus, the extensiveness of the offered services (emphasizes the breadth) and internal emphasis and revenue generation (depth) of each service offering, for each supplier-customer relationship, is important (Battisti et al., 2023; Partanen et al., 2017).

3. Methods

3.1. Questionnaire design

A research instrument was created for measuring the latent variable "Drivers for PSS". The questionnaire was built based on the literature review and modified to statements in a five-point Likert-type scale, ranging from 1 (totally disagree) to 5 (totally agree) (see Appendix A).

For evaluating semantic and theoretical the questionnaire, the content evaluation was applied. Three groups of professionals were involved in instrument endorsement. Graduate students with work experience in companies performed the semantic analysis. Professors of the production-engineering department from three Brazilian public universities carried out the content endorsement step (theoretical analysis). Two executives performed the research instrument endorsement: a senior project manager from the petrochemical sector and an executive from the communications sector. All comments and suggestions from experts and executives were analyzed and the questionnaire reviewed. One important suggestion adopted was the split of questionnaire drivers into three groups, namely: 'Strategic Scheme' (MF1), 'Product/Service Improvement' (MF2) and 'Environmental Impact' (MF3).

3.2. Sampling process

As exploratory research, we applied the theoretical sampling looking for experient executives and different types of PSS. Therefore, the first selection criterion was executives that are already pursuing the path to become PSS providers for at least five years. Secondly, a great effort was made to comprehend a gradient with three types of PSS: (i) Type 1- product-oriented; (ii) Type 2 – user-oriented; (iii) Type 3- result-oriented (see Figure 1). Finally, no distinction between the business-to-business and business-to-consumer approach was made.

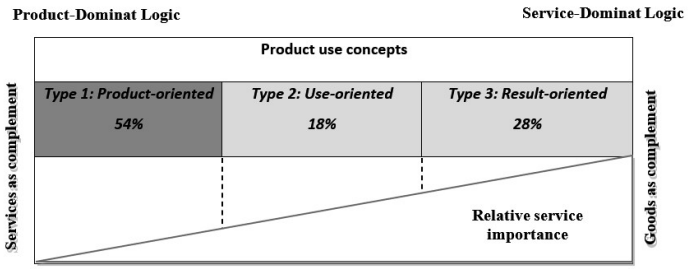

Figure 1. Profile of the companies surveyed – Product-Service Transition. Source: adapted from Baines et al. (2007), Oliva & Kallenberg (2003) and Vargo & Lusch (2004).

Before sending the questionnaire, the research team contacted all the potential respondent companies and discussed identifying a respondent in a relevant managerial position to evaluate the comprehensive nature of the service business. The target profile for the sample included professionals qualified to answer questions specifically related to the driven forces towards PSS. The research protocol was designed for one respondent per business unit.

Specific questions were explored to identify the company profile and to assist in the definitive sample selection. The final sampled companies were chosen for being considered a good set of representations of firms acting in Brazil. Product-service system providers from different sectors or company sizes were allowed. The Brazilian Support Service for Micro and Small Enterprises - Sebrae (2013) criterion for classifying firm size was adopted as shown in Table 1.

Table 1. Enterprize categories related to their annual gross income.

Category	Size	Description
1	Micro-enterprise	Annual Gross income < US$ 140 thousand
2	Small enterprise	US$ 140 thousand < Annual Gross income < US$ 1.4 million
3	Medium enterprise	US$ 1.4 million < Annual Gross income < US$ 180 million
4	Large enterprise	Annual Gross income > US$ 180 million

Source: Sebrae (2013).

Regarding the sample size, Hair et al. (2009) suggest a minimum observation number of five times the number of variables to be analyzed. Despite this orientation, it must be mentioned that this rule might lead to the statistical power of low acceptance levels (Henseler et al., 2009).

G*Power 3.0 software (Faul et al., 2007) was used to calculate the sample size. The parameters employed included ANOVA (repeated measures before factors). The parameters adopted to determine the sample size were Multiple Linear Regression: Random Model as a method, directional relation (two tailed) in the field "Input Parameters". For the effect size (H1 ρ^2) the value of 0.15 was adopted, classified as an average effect according to Cohen (1977, pg. 82). A significance level of 0.05 was specified, a required power of 80% according to the recommendation of Faul et al. (2007) and two predictor variables, resulting in a sample of 61 respondents. As mentioned in Section 1, this amount was surpassed, totaling 85 respondents.

3.3. Data analysis

The data collected in the survey were analyzed using descriptive statistical analysis and exploratory factor analysis. The software IBM SPSS Statistics was applied for calculation purposes and to reduce the 30 indicators (manifest variables extracted from the literature) based on the core factors representing the latent variable "Drivers for PSS" (Appendix A).

To determine whether the core factors in the data existed, the following parameters were considered: significance table (sig. or p-test) should present near-zero values; MSA (Measure of Sampling Adequacy) greater than 0.70; and Bartlett test of sphericity: p-value (significance test) not exceeding 0.05; Anti-image matrix over 0.50 and indicators should submit an explanatory power of at least 70%.

Another vital point considered was the minimum number of indicators per factor. Marsh et al. (1998, p. 182) indicate there seems to be a consensus that at least three indicators are desirable per factor, but under certain circumstances, two may be sufficient. This criterion is supported by Kline (2010) when he states that measurement models with more than a factor typically require only two indicators for identifying it.

4. Results

4.1. Sample demographics

The final sample was composed of 85 different companies in Brazil form different sectors and firm sizes (see Table 2). Regarding the gross annual revenues (US$), those with revenues between US$ 1.4 million and US$ 180 million correspond to 46% of the sample, which can be characterized as the medium company in Brazil, according to Sebrae (2013). The second group, with 34% of the sample, is composed of large companies, with a revenue above US$ 180 million.

Table 2. Sample characterization by operational area and size.

Organizational Sector	Number of Respondents	Annual Gross Income				Total%
		1	2	3	4	
Automotive	6	17%	0%	17%	67%	7%
Banking / Financial	4	0%	50%	25%	25%	5%
Construction	6	0%	0%	50%	50%	7%
Consulting	9	22%	33%	44%	0%	11%
Pharmaceutical	5	20%	0%	20%	60%	6%
Hospital / Health	3	0%	0%	100%	0%	4%
Industry	3	33%	0%	33%	33%	4%
Manufacturing Industry	4	0%	25%	25%	50%	5%
Metallurgical	5	20%	0%	20%	60%	6%
Media and Information	1	0%	0%	0%	100%	1%
Service Provisioning	11	0%	18%	73%	9%	13%
Projects	3	0%	0%	100%	0%	4%
Information Technology	13	0%	8%	54%	38%	15%
Telecommunications	9	11%	11%	33%	44%	11%
Transport and Storage	2	0%	0%	100%	0%	2%
Retail	1	0%	0%	0%	100%	1%
Total	**85**	**8%**	**12%**	**46%**	**34%**	

Source: Research results.

Considering the type of PSS, 54% of the sample is Type 1, 18% Type 2, and 28% Type 3. Thus, 46% of the sample represents the highest product-service integration towards a service-dominant logic (light grey in Figure 1) and 54% a product-dominant logic (dark grey in Figure 1).

We performed mood median test for significant differences in the answers accordingly type of PSS and sector, and no significant differences were identified.

4.2. Key variables in PSS adoption

The response distribution and the descriptive statistics for all the manifest variables are presented in Appendix A. Most manifest variables extracted from the literature were considered important by the respondent with a median of 4 or above. However, the most important manifest variable, with a median of 5, was MF 1.3 (new opportunities and market trends). Although the literature explores several variables related to environmental sustainability, three of them showed a lower median (3), namely: MF1.7 (higher focus on environmental issues), MF2.4 (reuse and recycling), and MF2.6 (product quality).

4.3. Exploratory factor analysis

Several iterative cycles of Exploratory Factor Analysis (EFA) were conducted, considering the following parameters: significance table (sig. or p-test); MSA; Bartlett test of sphericity: p-value (significance test); anti-image matrix. Since this research aims at identifying the minimum number of factors that explain the maximum portion of variance existing between the original manifest variables, Principal Component Analysis (PCA) was adopted.

As an exclusion criterion, manifest variables with low communalities (< 0.3) and substantial loadings on two or more factors, as well as items that did not have factor loadings on any factor (< 0.4), were removed (Stevens, 1986).

The validated nine factors are in Table 3, a solution which comprises 27 of the original 30 manifest variables. The excluded indicators are MF1.11 (customized price), MF2.1 (higher exchange of information), and MF2.5 (better information flow). All remain manifest variables have significant loadings on nine factors, each with eigenvalues greater than 1 (Tabachnik & Fidell, 2007). The nine-factor solution corresponded to those identified in the literature and explaining 76.2% of the variance in the data. All the manifest variables load onto their main factors, and most of them show no significant side-loadings, suggesting satisfactory discriminant validity.

Table 3. Factors and indicators codes after the Exploratory Factor Analysis.

Code	Factor	Indicator code
F1	Factor 1	MF1.4 - MF1.7 - MF2.10 - MF2.11 - MF3.1 - MF3.2 - MF3.3 - MF3.5 - MF3.6
F2	Factor 2	MF1.3 - MF1.5 - MF1.6 - MF1.10 - MF2.4
F3	Factor 3	MF1.9 - MF2.8 - MF2.9 - MF3.4
F4	Factor 4	MF1.1 - MF1.2
F5	Factor 5	MF2.2
F6	Factor 6	MF1.8 - MF2.7
F7	Factor 7	MF2.3
F8	Factor 8	MF1.12 - MF1.13
F9	Factor 9	MF2.6

Source: Research results.

According to Hair et al. (2009), a total explained variance of 73% is considered acceptable. The factor solution demonstrated a statistically significant Bartlett sphericity test (757.874 index, $p < .000$), while the KMO value (.719) was above the typical threshold of .5 (Kaiser, 1970), meaning the matrix is statistically significant and validates the use of Factor Analysis.

The validated PSS Drivers related to the corresponding factors load (from 1 to 9) and according to the factor's rotation method are shown in tables 3 and 4.

Table 4 shows the total variance explained based on the nine factors extracted. The Rotation Component Matrix of the EFA grouped into nine factors according to the eigenvalue recommendation (factor number 9; eigenvalue = 1.0346).

Table 4. Total Variance Explained – Exploratory Factorial Analysis.

Factors	Extraction Sums of Square Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.028	26.761	26.761	4.462	14.874	14.874
2	3.404	11.347	38.108	2.949	9.830	24.704
3	2.125	7.085	45.193	2.698	8.993	33.697
4	1.996	6.653	51.845	2.472	8.241	41.938
5	1.533	5.111	56.956	2.333	7.778	49.716
6	1.393	4.645	61.601	2.079	6.932	56.648
7	1.320	4.400	66.000	1.754	5.847	62.495
8	1.203	4.011	70.012	1.714	5.715	68.210
9	1.035	3.449	73.461	1.575	5.251	73.461

Note: Extraction Method: Principal Component Analysis.

Some level of Common Method Bias (CMB) may have occurred (Podsakoff et al., 2012); however, the method was considered at a level that did not compromise the interpretation of the results.

5. Discussion towards PSS drivers framework

In the previous section, we propose and validate a measurement model for PSS drivers. However, after the quantitative EFA, a qualitative analysis of the EFA, triangulating the field results with the literature, was conducted because the measurement model and the indicators "must be based on theoretical/conceptual reasoning before data collection" (Hair et al., 2009 p.67). This process, in addition to the argument that a latent variable should have at least two manifest variables, three factors lead to the exclusion of factors with only one indicator 5, 7, and 9 (see factors in grey in Table 3).

The discussion of the measurement model leads to six PSS drivers, namely: environmental sustainability (F1), competitive advantage (F2), co-production (F3), portfolio (F4), integrated solution (F6), and co-creation (F8). The factors name aims to represent the meaning of the variables grouped as described in the assertions of the manifest variables (see Appendix A).

The environmental sustainability (F1) is one of the most discussed in PSS literature, and in the field research, it is composed of nine manifest variables, including aspects related to product end-of-life solutions, recycling, reuse, product disposal, lifecycle extension, minimizing the environmental impact with an inherently lower environmental burden. The striking result indicates that a growing number of companies are more aware of the legal need to incorporate environmental concerns into their activities, mitigating the effects of PSS on environmental aspects. However, the exogenous pressure through the penalties applied by regulatory, governmental agencies in the case of environmental breaches has a significant role (Aloise & Macke, 2017).

Regarding the competitive advantage (F2) driver, it is composed of five manifest variables as a response to customer demands, adding competitive advantage that both services and products alone are not able to provide, organization networks expansion, new product/service market trends, capture value through reuse and recycled parts. F2 brings lights on the value perspective on both aspects the leading firm and the share value among players, which is a relevant question concerning the various types of complementarities in economic relationships (Jacobides et al., 2018; Kühl et al., 2023; Li et al., 2023).

The co-production (F3) driver consists of four manifest variables, such as share core competence from the customer, more control over the process, flexibility, detachment of value from the physical goods delivery. It brings insights into the exploration of operand resources in co-production, by sharing expertise and smoothing the revenue streams while sharing risks (Baines et al., 2020; Santamaria et al., 2016; Wang et al., 2023).

The portfolio driver (F4) has only two manifest variables, portfolio expansion and diversification. However, it plays a tactical role and, if well-orchestrated, it can enhance and potentialize all the other factors as co-production (F3), integrated solution (F6), and co-creation (F8). Moreover, as a natural consequence, the establishment of networks allows new collaborative competence and new business opportunities, making the shift in the portfolio (Baines et al., 2007; Boehm & Thomas, 2013; Neely, 2007).

The integrated solution (F6) driver consists of two manifest variables. F6 explores how an integrated solution dynamic reaches the increasing needs of customer demands by selecting each customer's preference and sharing risks for both sides concomitantly.

The co-creation (F8) driver is also composed of two variables: the customer actively involved and innovative value creation. It indicates that exploring PSS provider and customer value co-creation processes opens the opportunity of identifying innovative ways to value co-creation and enables the market adoption of product innovations (Haber & Fargnoli, 2017, 2019; Sakao et al., 2017; Zhao, 2022).

The among drivers can be structured at a distinctive level exploring how the ecosystem-mediated different types of complementarities and relationships (Jacobides et al., 2018; Li et al., 2023). Figure 2 shows the drivers structured in three levels of analysis - PSS strategic level, the ecosystem complementors and customer level, and a tactical level, portfolio, bridging both previous levels. The first most strategic PSS drivers are environmental sustainability (F1) and competitive advantage (F2), which are related to PSS provider as the leading firm in the ecosystem but also explore variables related to shared value (Moro et al., 2022). Three drivers are strongly connected with the complementors and customers in the PSS ecosystem (F3, F6 and F8), representing formal or informal relationships between leading firms, complementors and customers towards integrated solutions, co-creation, and co-production. A point for future research is to incorporate the discussion of platforms as enablers for the relationship among these factors through integrated product/service business models (Cenamor et al., 2017). At the tactical level is the F4 looking for bridging the strategic perspective (F1 and F2) to the ecosystem level (F3, F6 and F8). In this level, both aspects appear the cross-business-model portfolio synergies and intra-business-model portfolio complementarities (Dmitrijeva et al., 2020).

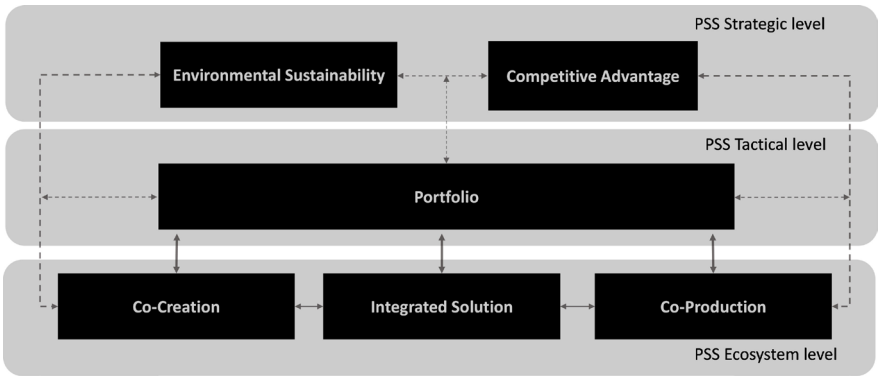

Figure 2. Drivers for Product/Service-system Framework in the Brazilian context. Note: The thickest the line, the strongest the connection among the drivers according to the EFA results.

In Figure 2, the arrows represent potential relationships to be explored. For instance, the relation among portfolio (F4) and to the ecosystem level (F3, F6 and F8) is more connected. It suggests that an essential point for future research is to understand the nature and direction of the dependencies and the extent of the underlying complementarity in the ecosystem (Jacobides et al., 2018; Li et al., 2023). Furthermore, the connections between the other factors and environmental sustainability (F1) sometimes are built through the influence of exogenous factors as regulations (Kühl et al., 2023). In that case, any misalignment or failure regarding environmental aspects may represent drastic consequences to the image of the stakeholders involved (Battisti et al., 2023; Pakdeechoho & Sukhotu, 2018).

6. Conclusions

This study contributes to the literature in three ways; first, by identifying the key drivers for organizations moving on towards product-service system offers, which are environmental, competitive advantage, co-production, portfolio, co-creation and integrated solution. Second, it provides a PSS driver's framework that explores the six drives and its relations in a three-level perspective of analysis. Finally, the third, the present study also proposes a research instrument initially based on the literature review and validated by statistical procedures - Exploratory Factor Analysis (EFA) that may be used by other researchers in further in-depth scholar studies.

This study holds managerial implications as it offers companies a valuable tool in the form of a questionnaire. It serves as a reference checklist for investigating potential drivers of PSS and enables them to assess if the servitization pathway aligns with their organizational expectations in a balanced manner, once deservitization

path (Battisti et al., 2023) might require waste of resources and ecosystem reconfiguration (Li et al., 2023). Although digitalization and technology has come to address some operational issues, regarding equipment interaction with customers, in our perspective, the main issues are related to strategic, tactical e co-creation processes, once the whole organization needs to be prepared for the number of inputs coming from the network interactions (Kurpiela & Teuteberg, 2022) and further ecosystem deployment (Li et al., 2023).

This research has certain limitations that should be acknowledged. Firstly, due to the non-probabilistic sample, the findings cannot be generalized. Secondly, like many survey-based studies, the results do not capture the dynamic processes involved in establishing the identified relationships between the variables.

However, this study opens new insights for future research, since the relationship between each factor and its indicators should be deployed in-depth, identifying current archetypes configurations regarding the digitalization issues. Additionally, the nature and direction of the dependencies in the ecosystem need to be further investigated. Second, the evolution of the importance of each factor according to the maturity of PSS providers in offering integrated solutions could also be further explored. Third, an in-depth investigation of the role of complementarities in both sense cross-business-model portfolio and intra-business-model portfolio. Finally, some control variables could be explored, such as firm size, sector, and country.

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Appendix A. Drivers for PSS questionnaire: scale items and descriptive statistics.

Item	*Code*	*Scale items*	Mean	Std. Dev.	Median	References
1	MF 1.1	PSS offering expands the portfolio of products/services.	4.306	0.7719	4	Baines et al. (2007), Boehm & Thomas (2013), Neely (2007)
2	MF 1.2	PSS offering diversifies the portfolio of products/services.	4.247	0.7222	4	
3	MF 1.3	PSS offering enables companies to **respond to customer demands** and new opportunities and market trends.	4.377	0.7556	5	Zhao (2022), Haber & Fargnoli (2017, 2019), Sakao et al. (2017).
4	MF 1.4	Companies adopt PSS as a natural **extension of their offerings** to customers, and some even regard this system as a **new business plan**, enabling market adoption of **business process innovations.**	4.023	0.8448	4	Baines et al. (2020), Moro et al. (2022); Coreynen et al. (2020)
5	MF 1.5	PSS offering brings a **competitive advantage** to the services and the products that could not have been added in isolation.	4.223	0.7773	4	Baines et al. (2020), Baines et al. (2007)
6	MF 1.6	PSS offering allows companies to create **inter-organizations networks** for providing other services, creating collaborative competences.	4.059	0.807	4	Dmitrijeva et al. (2020), Li et al. (2023)
7	MF 1.7	PSS providers are more focused on issues related to **environmental dimensions** than traditional companies.	3.212	0.977	3	Mont (2002), Baines et al. (2007)
8	MF 1.8	PSS providers **have more potential to meet the preferences of consumers** than traditional ones.	3.8	0.9103	4	Zhao (2022), Wang et al. (2023)
9	MF 1.9	PSS offering allows **flexibility of payment methods** such as payment for use, for rent, for lease, with smooth revenue streams.	3.753	0.975	4	Kurpiela & Teuteberg (2022)
10	MF 1.10	PSS offering enables **new product use proposals and/or services**, designed to meet specific customer needs.	4.188	0.6636	4	Zhao (2022), Wang et al. (2023)
11	MF 1.11	In PSS, the **pricing proposal is unique and depends on the package** singularities offered to the customer.	3.752	0.8438	4	Kurpiela & Teuteberg (2022)
12	MF 1.12	In PSS, the customer becomes a **value co-creator.**	3.718	0.8812	4	Zhao (2022), Haber & Fargnoli (2017, 2019), Sakao et al. (2017).
13	MF 1.13	When the customer takes part in co-creation, the possibility of identifying **innovative ways of value co-creation emerges** and enables market adoption of product innovations.	3.929	0.8562	4	
14	MF 2.1	PSS in which the customer becomes co-producer, there is an incentive to **exchange information**, by understanding customer operations and developing relationships, resulting in higher customer intimacy.	4.188	0.5668	4	Wang et al. (2023), Dmitrijeva et al. (2020), Kühl et al. (2023)
15	MF 2.2	PSS, in which there is co-production, the **customer takes part** in the **elaboration of the customized solu**tion.	3.953	0.7055	4	Zhao (2022), Haber & Fargnoli (2017, 2019), Sakao et al. (2017)
16	MF 2.3	**Greater interaction** between PSS provider and the customer **increases the knowledge about the product.**	4.423	0.6244	4	Wang et al. (2023), Dmitrijeva et al. (2020), Kühl et al. (2023)
17	MF 2.4	PSS in which the customer does not own the product, the possibility of **reusing parts and material recycling increases.**	3.388	0.8877	3	Mont (200)2, Baines et al. (2007), Kjaer et al. (2019)
18	MF 2.5	**Information flow** between PSS provider and customers **is more accessible.**	3.235	0.972	3	Wang et al. (2023), Dmitrijeva et al. (2020), Kühl et al. (2023)
19	MF 2.6	Using PSS, service companies can maintain a certain product **quality level.**	3.294	0.8974	3	Manzini & Vezzoli (2003), Vasantha et al. (2015).
20	MF 2.7	In PSS that involves co-production, the company tends to **share the risk with the customer**, and, in some cases, these results in decreased risk.	3.6	0.8891	4	Battisti et al. (2023), Mont (2002, Gebauer et al. (2005)
21	MF 2.8	When a **customer** knows a particular core competence, he becomes more **prone to participate as a co-producer** of the solutions to PSS offering.	4.035	0.6627	4	Wang et al. (2023), Dmitrijeva et al. (2020), Kühl et al. (2023)
22	MF 2.9	In PSS, there are natural **tendencies towards co-production** when the customer wants more control over the process or result of the service.	3.788	0.773	4	Wang et al. (2023), Dmitrijeva et al. (2020, Kühl et al. (2023)
23	MF 2.10	PSS **allows providing maintenance services and integrated product repair.**	4.094	0.6478	4	Mont 2002), Bocken et al. (2017)
24	MF 2.11	PSS **enables the use of the maximum capacity of the product purchased.**	3.741	0.7891	4	Mont (2002), Vasantha et al. (2015, Bocken et al. (2017)
25	MF 3.1	PSS facilitates the creation of solutions to products **end of life and lifecycle extension** (reusable products, easily replaceable and recyclable parts).	3.907	0.83	4	Bocken et al. (2017), Kjaer et al. (2019)
26	MF 3.2	PSS enables the **reduction of environmental impacts** due to the change in property ownership – often, the client does not know how to reuse parts or discard the product.	3.833	0.841	4	Mont (2002), Baines et al. (2007), Kjaer et al. (2019)
27	MF 3.3	In PSS, when the ownership remains with the provider, there is a **potential to minimize the costs through long-lasting products** and proper operation observance.	3.685	0.843	4	Battisti et al. (2023), Moro et al. (2023), Mont (2002), Baines et al. (2007)
28	MF 3.4	PSS has the potential to **detach the idea that the value delivered to the customer is directly related to the amount of physical equipment** necessary to generate value.	3.611	1.123	4	Mont (2002), Baines et al. (2007), Kjaer et al. (2019)
29	MF 3.5	PSS has the potential to create products and services that offer customers the same level of performance, but with a **lower environmental load.**	3.778	0.861	4	
30	MF 3.6	PSS has the **potential to reduce production and consumption material flow**, creating products and services that provide consumers with the same level of performance, but with a lower environmental load.	3.63	0.896	4	