

Enhancing the design and management of the product-service system (PSS) supply chain: an application to the automotive sector

Abstract. The proper design and management of product-service system (PSS) supply chains is a prerequisite for the successful implementation of servitised business models. As underlined by empirical evidence, research on how different types of PSS offerings affect the design and management of the upstream supply chain of PSS providers still appears to be lagging. Therefore, this paper introduces a theoretical explanatory conceptual framework derived from a literature analysis and further developed by four case studies from the automotive sector, which highlight the linkages between the value proposition and supply chain of PSS providers. The results are summarised into 11 propositions that underline the key roles and capabilities that bridge PSS offering features with distinctive characteristics of the PSS supply chain. They also show specific patterns of partners' relationships and organisational configurations that can be identified during the servitisation transformation.

Keywords: Product-service system (PSS), Servitisation, Supply chain management, Supply chain design.

1 Introduction

The widespread decrease of profit margins in product sales, coupled with changing customer expectations, is driving manufacturing companies to find additional sources of profit. Extending traditional offerings to the provision of integrated product-service bundles (Velamuri et al., 2011) seems to be the natural response of many firms. This transformation, also called the 'servitisation of manufacturing' (Vandermerwe and Rada, 1988), started at the beginning of the 1990s (Davies et al., 2006) when several manufacturing firms began to introduce services in their offering to varying extents. It represents the evolution of companies' business models 'from a 'pure product' orientation towards an integrated product-service system (PSS)' perspective (Gaiardelli et al., 2014). The adoption of a servitisation strategy provides several advantages for manufacturers, such as higher profit margins, more stable sources of profits and lower cash flow vulnerability, which is a powerful strategic weapon and marketing argument to sell more products (Baines et al., 2007; Mathieu et al., 2001). The potential environmental and social benefits of decoupling asset ownership from use through the introduction of product-service combinations (Tukker, 2004; Vezzoli et al., 2012; Chou et al., 2015) were also analysed in the literature.

Despite several successful stories of servitisation (IBM, Rolls-Royce, Xerox, Rockwell Automation, etc.), many manufacturers have encountered difficulties to achieve success in the service world after investing substantial resources in their service businesses (Gebauer et al., 2005; Neely, 2009). Empirical evidence has, therefore, made evident that this journey is scattered with obstacles and requires several modifications (Martinez et al., 2010) in all areas of a company's business model, in an gradual, controlled and systematic fashion (Kindström, 2010). Changes are required not only internally (Gebauer et al., 2005), but also externally. These include both downstream modifications towards customers (Vargo and Lusch, 2004) and upstream modifications towards suppliers and partners (Windahl and Lakemond, 2006).

Therefore, the purpose of this paper is to contribute to the understanding of the servitisation concept by examining how manufacturing firms design and manage their supply chains to enable effective and efficient delivery of PSS solutions. It is particularly important to understand the appropriate dimensions necessary for analysing PSS offerings and the value they assume according to various levels of servitisation, which can be understood as different degrees of product-service offering sophistication (Martinez et al., 2010). Moreover, this work, which draws upon four case studies, aims to investigate how these different PSS dimensions affect the design and management of the supply chain of a manufacturing company (PSS provider) that provides such offerings.

The remainder of this paper is organised as follows: Section 2 introduces the theoretical background and research questions. Section 3 describes the research design phases, including the development of the conceptual model. Section 4 discusses results and findings from the case studies. Lastly, Section 5 closes the paper with research contributions, managerial implications and recommendations for future research directions.

2 Theoretical background and research questions

Thanks to the notable growth of managerial and scientific studies over the last 15 years, the servitisation phenomenon has been explored, described and critically analysed by both scholars and practitioners (Baines et al., 2016; Lightfoot et al., 2013b). However, little agreement has been reached among scholars in spite of these large and extensive research activities. The disaggregated and fragmented nature of the field is proved by the existence of disconnected silos of knowledge, distinguished by different contents of investigation, terminologies, definitions, theories and methodologies, from sociological to engineering disciplines, and from a traditional customer-centric to a sustainable network-based stakeholder approach (Gummesson, 2008). Such divisions have contributed to the existence of several gaps of knowledge in the field (Baines et al., 2009; Pawar et al., 2009; Velamuri et al., 2011).

Despite such differences, there is agreement in the scientific community that the evolutionary process of servitisation calls for a thorough change in manufacturers' business paradigms and dominant logic (Bettis and Prahalad, 1995). The 10 functional premises that form the basis of the service-dominant logic (SDL) perspective (Vargo and Lusch, 2004) demonstrate the deep transformation of business perspectives from a technocratic to a customer-centric culture, where business should be (re-) conceptualised by managers and all of the relevant strategic, tactical and operative decisions should be (re-) defined.

In order to move towards a new dominant logic, it is necessary to surmount the 'organisational stability' hill (Bettis and Prahalad, 1995), with the creation of a profound change in the mind set pervading the entire organisation and its supply chain (Figure 1).

<INSERT FIGURE 1>

Therefore, servitisation cannot be described only as the inclusion of additional elements in a company's service offering portfolio or the proposal of integrated solutions. Rather, it can be defined as the gradual and consistent evolution of a manufacturing firm's entire business model (Teece, 2010; Zott et al., 2010), comprising its value proposition, capabilities and organisational structure, role and position in the supply chain for value creation, as well as its relationships with customers. Consequently, a PSS can be defined as a servitised business model.

An abrupt change in a business paradigm can cause a traumatic reaction in an organisation, preparing the way for a 'service paradox' (Gebauer et al., 2005). To reach a new equilibrium, a consistent and integrated design and management of innovative PSS business models is required (Figure 2), which will guide the incremental evolution from a transactional product-oriented approach to the market to relational result-oriented solutions (Tukker, 2004).

<INSERT FIGURE 2>

Several research gaps still exist in the field that hinder a comprehensive understanding of the servitisation phenomenon. Since not all situations warrant the same approaches to the change in servitisation, a standard transition process that overcomes all challenges cannot be defined. On the contrary, companies may employ different combinations of paths to reach new equilibrium positions in response to particular market requests (Kowalkowski et al., 2015). Questions still remain about the nature of evolution trajectories (Baines et al., 2016), and scant attention has been dedicated to the dispute about elements that can either accelerate or delay the solution to this problem, thus facilitating or hindering the transition

from one trajectory to another. Specifically, the analysis on barriers and enablers has concentrated mostly on the examination of a business model only, which neglects the supply chain perspective. Finally, in order to understand how the servitisation transformation occurs, it is important to recognise the content of such an evolution (Figure 1), i.e., the way a manufacturing firm creates value, also known as its business model (Shafer et al., 2005). Indeed, when characterising and describing the new equilibrium achieved with servitisation, a large number of existing studies conceptualises servitised offerings as a single strategic response. By contrast, there might be diverse types of product-service systems and the linkage between a product-service strategy and performance could be mediated by different business model configurations. In particular, referring to the content of a servitisation transformation, there is a lack of understanding about the links between value propositions and value creation in enlarged supply chains and networks where buyers and suppliers are intertwined for the delivery of complex service strategies (Baines et al., 2016).

This paper focuses on the upstream supply chain, which is engaged in designing and delivering the PSS and aims to answer to the following research question: How does the servitisation level of a PSS offering affect a PSS provider's supply chain content?

In particular:

- RQ1: How does the servitisation level of a PSS offering affect **the design** of a PSS provider's supply chain?
- RQ2: How does the servitisation level of a PSS offering affect **the management** of a PSS provider's supply chain?

3 Research design

An exploratory case-based approach was identified as the most appropriate methodology because this research work deals with a 'how-type' question about a current phenomenon that has yet to be thoroughly investigated (Voss et al., 2002; Yin, 1994).

3.1 Development of the conceptual model

In theory building research, a preliminary understanding of the principal constructs and their connections is needed no matter how inductive the approach (Voss et al., 2002). As recommended by Miles and Huberman (Miles and Huberman, 1994), this can be accomplished by building a conceptual model that lies beneath the research. Such a model describes the main features that have to be considered and their supposed interactions. A conceptual model can be employed to outline a phenomenon, not explain it (Meredith, 1993).

The conceptual model presented in this paper was developed based on a structured literature review of servitisation and PSS (Resta, 2012), which considered a large number of keywords associated with these two concepts (i.e., servitisation, PSS, service infusion, hybrid value creation, integrated solutions, functional products, customer solutions, service dominant logic, etc.).

As previously explained, decisions about designing, configuring and managing the new equilibrium are critical subjects that PSS providers need to face. Compared with the traditional good manufacturing logic (Vargo and Lusch, 2004), when services and products are added together the sophistication of corporate configuration intensifies, both internally and externally (Becker et al., 2010). Nearly every feature of the business model has to be transformed, from strategy and position in the value creation network to organisational structure, capabilities, and culture (Oliva and Kallenberg, 2003). Specifically, different human resources and skills might be necessary (Gebauer and Friedli, 2005) and new business units could be established to enable the progress towards customer-centred services, which could have an impact on the relationships between the business functions within the company and the whole organisational structure (Davies et al., 2007; Galbraith, 2002; Neu and Brown, 2008; Oliva et al., 2012). Furthermore, since the development of a PSS frequently entails capabilities and resources that might not be found in the company (Davies, 2004; Paiola et al., 2013), collaboration with other partners and suppliers might be required (Pawar

et al., 2009; Spring and Araujo, 2009) where all but core competencies can be outsourced (Baines et al., 2009). The transformation of the supply chain (Vargo and Lusch, 2004) is characterised by varying stages along a 'collaborative continuum' (Mathieu, 2001) that encompasses not only the actors essential for the manufacturing of the physical goods, but also the partners having control over the delivery of service components (Cohen and Agrawal, 2006; Schweitzer and Aurich, 2010). In this way, a PSS provider is able to acquire competencies through alliances and partnerships, thus resulting in greater value for customers. In this context, the degree of integration between organisations should correspond to the degree of integration between the products and services (Slack et al., 2004).

Thus, it is fundamental to investigate how different types of PSS offerings affect the design and management of the upstream supply chains of PSS providers (Lockett et al., 2011) in relation to different levels of PSS offering servitisation. The constructs and variables evaluated in this research are included in the initial conceptual model (shown in Figure 3) and are described as follows:

PSS value proposition is the blend of products and services offered and denotes the value to the customer for which he or she is willing to pay. It can be represented by means of three variables (Gaiardelli et al., 2014):

- *Orientation* - ownership, use and decision-making power (product-, use- and result-oriented);
- *Focus* - objective of the service (product vs. processes);
- *Nature of the interaction between the customer and the PSS provider* (transaction-based vs. relationship-based).

The PSS supply chain design defines the supply chain architecture in terms of the internal departments and external partners involved in the co-creation and delivery of PSS value propositions and how relationships between PSS providers and partners are managed (Melnik et al., 2014), including (Aurich et al., 2010; Resta et al., 2016):

- *The PSS provider* - focal point of the supply chain. It is the manufacturing firm that creates and manages the PSS value proposition(s) provided to the customers;
- *The product supply chain* - suppliers of product parts, components, and modules;
- *The service supply chain* - suppliers of services;
- *The PSS provision supply chain* - branches and service delivery centres of the PSS provider, as well as independent distribution and service partners.

PSS supply chain management describes the relationship between mechanisms within the PSS supply chain (Gaiardelli et al., 2011; Resta et al., 2016), in particular:

- *Intra-organisational* relationships among business functions (Johnstone et al., 2008; Oliva et al., 2012; Sawhney et al., 2004; Storbacka, 2011; Tuli et al., 2007; Windahl and Lakemond, 2006);
- *Inter-organisational* interactions between a company and other actors of the PSS supply chain (Baines and Lightfoot, 2011; Chakkol et al., 2014; Finne et al., 2015; Johnson and Mena, 2008; Kohtamäki et al., 2013; Lockett et al., 2011; Matthyssens and Vandenbempt, 2010; Pawar et al., 2009).

<INSERT FIGURE 3>

3.2 Level of analysis and sample selection

As the paper aims at exploring the influence of different PSS offerings, characterised by diverse levels of servitisation, on the upstream supply chain of a PSS provider, a multiple-case study method was selected. The cases were chosen consistently with a theoretical (analytical) sampling to illuminate and extend the relationships between the constructs. The cases were explicitly selected to represent various servitisation levels. With the purpose of isolating the effects of the strategic context from other potentially confounding

aspects, the case studies were picked from a single macro-sector: the automotive industry. The sample, represented in Table 1, comprised 13 offerings from four companies. In terms of the ‘orientation’ variable, nine cases refer to the product-oriented area and four to the use-oriented category. Even if result-oriented solutions exist in the automotive sector, currently they are provided by pure service firms and not by manufacturers. Therefore, such solutions are not included in the research design because servitization is a phenomenon encompassing manufacturing companies and not to service providers.

Table 1. Description of cases.

Case study	Type	PSS value proposition		Main variables			Interviews
		Product offering	Service offering	Orientation	Focus	Nature of interaction	
Truco	Headquarter (Italy)	Light, medium, heavy and specialty vehicles	Repair services	PO	PD	TR	4 (after-sales services, spare parts logistics, network development, customer centre)
			Teleservices	PO	PD	RL	
			Repair & maintenance contracts	PO	PD	RL	
			Roadside assistance	PO	PD	RL	
			Training	PO	PR	RL	
			Fleet management	PO	PR	RL	
Tenco	English branch of a German group	Commercial vehicles and transport solutions	Repair services	PO	PD	TR	7 (sales, after-sales services, marketing, spare parts logistics, network development, customer centre and financial services)
			Repair & maintenance contracts	PO	PD	RL	
			Fleet management	PO	PR	RL	
			Contract hire	UO	PR	RL	
Carco	Italian branch of a French group	Automobiles	Leasing	UO	PR	RL	3 (after-sales services, network development, financial services)
			Long-term renting	UO	PR	RL	
Elmoby	Italian branch of a German subsidiary of a German group	Premium cars, buses and trucks	Electric mobility	UO	PR	RL	4 (after-sales services, network development, financial services, marketing)
Orientation		PO: product-oriented; UO: use-oriented; RO: result-oriented					
Focus		PD: product-based; PR: process-based					
Nature of interaction		TR: transaction; RL: relationship					

3.3 Data collection, analysis and coding

Data were collected through semi-structured interviews with managers belonging to the following departments: sales, after-sales services, marketing, spare parts logistics, network development, customer centres and financial services. The line of questioning in the interviews was developed using a conceptual model (described in Section 4) and was included in the case study protocol. Even if the initial set of interviews was agreed upon during the first meeting, the list of informants was extended through recommendations from the interviewees. The variety of informants provided a complete picture of the phenomenon being studied and helped ensure construct validity. Furthermore, having multiple researchers

collecting information from several respondents helped moderate possible sources of bias. Lastly, direct observations and extensive reviews of secondary data, such as firm documentation, reports and websites, were used for triangulation, which guaranteed the internal consistency of the data.

The data analysis had two main components: within- and across-case analyses. For each case, the within-case analysis helped provide a static view of the PSS. On the contrary, the across-case analysis helped understand the relationships between the constructs (systemic/transformational approach). During each visit, the interviews were taped and afterwards transcribed. Then, a draft of the case study report was written, mostly from one researcher's field notes, and reviewed by another interviewer who also inserted follow-up questions to clarify and extend the content. Eventually, the summary was sent to the informants for their validation and debated during a follow-up meeting. Coding and within-case analyses began once all the data was collected. To minimise bias during the data analysis, researchers coded the data independently, afterwards compared their coding as a validity check for each case. After that, the researchers jointly assessed the relationships between the elements for each case. The coding process for each case did not advance until the researchers reached an agreement on the constructs and their relationships. Eleven propositions were determined based on the conceptualisations and findings, as described below.

4 Presentation and discussion of results

For each case reported in Table 1, constructs and variables identified in the conceptual model (Figure 3) were described and further summarised (see Tables 2, 3, 4 and 5 in the Appendix). A cross-case analysis was then carried out and the main similarities and differences between the cases were identified and discussed. As described in the following sections, 11 research propositions (Ps) were derived from the discussion and included in Figure 2, representing the final research model.

4.1 The evolution of the PSS supply chain design

External partners. A manufacturing firm that moves into the service domain requires the development (make) or acquisition (buy) of new capabilities (knowledge and skills), depending on the type(s) of offerings introduced in its product portfolio, in order to achieve a proper alignment between the product-service offering and the operating resources available to them (Vargo and Akaka, 2009). Such 'make or buy' decisions determine the amount of external relationship management needed. Particularly, as demonstrated by all the case studies, product-based services necessitate technical capabilities on the product and on its parts.

P1: PSS offerings focused on products are related to the traditional technical capabilities of the product.

Since original equipment manufacturers (OEMs) already have an intimate understanding of the product they have designed and developed, they are well positioned to deliver services to inspect, maintain and upgrade a vehicle during its use. Since the capabilities required for such offerings are close to the traditional technical capabilities of a PSS provider, product-based services are managed and delivered directly by the firm or through its assistance network. The latter can be defined as the external reflection of the internal sales and after-sales functions. It can be composed of OEM-owned or franchised dealers and workshops, or both. Nevertheless, as proved by the Elmoby case, the sales and assistance network can play an intermediary role as the main interface with customers where customers can turn not only for technical assistance on the product, but also to create the first contact point with other actors who are responsible for the PSS delivery. Furthermore, a product supplier can also become a PSS supply chain partner, particularly for critical components when an innovative technology is in the introductory phase.

P2: The traditional technical capabilities of a product are delivered directly by the PSS provider, usually with the support of its assistance network.

In contrast, the introduction of offerings with a focus on how the customer uses a product encompasses two different types of capability. On one hand, it is necessary to comprehend customers' activities and the processes involved in owning and using a product through the development of

consultancy capabilities. For instance, in the Tenco case, consultancy capabilities are developed internally by means of training programs delivered to the sales force to become 'transport consultants'.

P3: The shift in focus from products to processes requires consultancy capabilities.

P4: The need for consultancy capabilities involves the transformation of sales representatives into consultants who are able to understand customers' activities and processes.

On the other hand, capabilities related to specific services are required to complement PSS providers' core capabilities related to a product. Examples include the fleet management competencies for fleet management services provided by Tenco and Truco and the educational competencies for training services delivered by Truco to the assistance network.

P5: The shift in focus from products to processes entails an increasing need for specific capabilities related to the services provided.

Since the requested capabilities are not intimately related to the PSS provider's traditional capabilities, external partners (competing in industries that are different from the automotive sector) usually act as sources of complementary capabilities. In particular, with a shift in focus from products to customers' processes and activities, the assistance network loses its role as a service delivery partner in the PSS supply chain, whereas the sales network keeps its front-end role. The partners act both as service suppliers for the PSS provider and as direct service providers for the customers. Although the PSS provider holds a high degree of vertical control in the sales and assistance networks, the service suppliers (which can behave also as service providers) are connected to the focal company by means of partnership relationships. In addition, the Carco case demonstrates that there can be several layers of partnerships, e.g., a financial company (service partner) has a partnership with an insurance company that provides customers with financial and insurance services. In particular, grounding in the S-D logic paradigm developed by Vargo and Lusch (2004), the PSS provider becomes the focal point of a service ecosystem (Lusch, 2011; Vargo and Akaka, 2012), which can be intended as a set of nested supply chains, acting as integrator of external resources (Vargo and Lusch, 2008).

P6: The need for specific capabilities related to the services provided, including non-traditional technical capabilities, requires the involvement of external partners that are generally competing in industries different from the automotive sector.

For services that need new technical product characteristics, external technical product partners could be required. For example, in the Truco case, fleet management services required new technical product characteristics (i.e., telematics tools installed on the vehicles), while in the Elmoby case, service was a way to foster a new technology (electric vehicles).

P7: Process-oriented PSS offerings could also require the product to be redesigned, which requires non-traditional technical capabilities.

Internal departments. Traditionally, the after-sales department is in charge of firm's technical support processes and has a principal role in providing and managing product-focused offerings. Moreover, the after-sales department manages activities associated to the spare parts business (logistics and pricing), as well as technical support activities. Nevertheless, traditional after-sales services (i.e., repair and maintenance, extended warranties, inspection and diagnosis, etc.) are only one category of service that a manufacturing company can possibly offer to its customers since the lifecycle of a product has many pockets of value. In the same way, the after-sales unit is only one of the functions involved in the service provision. For instance, the sales function plays an important role in the service area. Conventionally, the sales function refers to the business unit that is in charge of selling (directly or through a dealer) a firm's traditional product offering. With the introduction of new services, the sales function holds both product and service responsibilities, and the salesmen become the first customer-provider interface for both the product and the service domain. In order to encourage the sales force to promote and sell services to the customers, all the companies in the case studies provided bonus schemes where a quota of the incentives were linked to the number of service contracts sold. Hence, sales force activities should be oriented to co-creating customer's value, helping customers assess their needs and identifying/developing the most suitable solution(s) (Hass et al., 2012). The marketing function (or business development) also played a

significant role in promoting new offerings in the market (Elmoby), as well as in understanding the market's needs and segmenting customers. Finally, the engineering department was responsible for managing external technical product partners.

P8: The internal service organisation involves after-sales, sales and marketing functions.

P9: The requirement of innovative technical product features entails the involvement of the engineering department in the product design phase.

4.2 The evolution of PSS supply chain management

Intra-organisational relationships. In all the companies explored in the case studies, the after-sales function was at the same hierarchical level as the product-related functions, and it was not considered a cost but a profit centre with its own responsibility for profits and losses. In product-oriented offerings, the after-sales department is mostly perceived as isolated from other organisational functions and every function works independently with its own informal coordination activities. However, as the value proposition shifts from unbundled to bundled offerings, the need for formal synchronisation rises through cross-functional information and communication flows and shared databases including customers' data. Thus, the sales, after-sales and marketing functions should work closely together, preferably in a symbiotic connection. The autonomy and independence of the service side of the business help to build momentum, but they must not lose their critical points of contact with the product side of the business, i.e., service activities provide access to operational information about the products, which can be used to improve the development and quality of the next generation of products. In the Truco case study, the engineering department benefited from feedback about the product's quality, which was collected by the after-sales and marketing departments through the assistance networks and telematics instruments installed in the vehicles. In line with the revised S-D logic foundational premises (Vargo and Lusch, 2008), the after-sales department acts as integrator of internal resources required in a servitization transformation and in the design and management of product-service offerings.

P10: Internal functions involved are managed by the after-sales department of the PSS provider with increasing need for formal synchronisation between the units involved.

Inter-organisational relationships. For product-oriented PSS offerings, the PSS provider has a high level of vertical control over the PSS supply chain through the standards included in the legal contracts. Moreover, strategic goals are determined centrally by the PSS provider and then applied to the network with the development of suitable key performance indicators (KPIs) and their target values. The fulfilment of the appointed goals is related to reward schemes, which are built on the technical aspects of the service provision process and its quality. Truco and Carco introduced bonuses linked to customer satisfaction. Other incentives related to the service area are given to the sales force of the PSS provider in accordance with the number of service contracts sold. No company has a horizontal reward system that cuts across the business functions, nor has any company offered compensation based on customer satisfaction (except for Truco's assistance network) nor corporate/business cluster outcomes. When external partners that are competing in sectors different from the automotive industry deliver desired capabilities, the PSS provider has a lower level of control over the actors in the supply chain. Therefore, it can be argued that service ecosystems are kept together by means of ties characterised by different degree of intensity and control, and enable unrelated organisational networks to build larger macrostructure that can be more agile, fluid and adaptable (Lusch et al. 2010). Such service ecosystems allow capabilities and resource interaction in terms of combination, re-combination, and co-development of required capabilities that happen through the interaction among organisations (Baraldi et al., 2012).

P11: The PSS provider maintains a high level of control over the PSS assistance network. Horizontal relationships take place with other external partners that are usually competing in industries different from the automotive sector.

In summary, the servitisation level of the PSS offering directly influences the capabilities required for its design and delivery, as described in propositions P1, P3, P5 and P7. Service provision activities do not

encompass only the after-sales department and other internal functions; other possible roles of various third-parties in the PSS supply chain must be taken into account. The 'virtual' sum of the corporate functions and partners contributing to service design, provision and management, constitutes the service organisation (as represented by P2, P4, P6, P7, P8, P9). As a virtual enterprise, the involved internal and external actors provide complementary core competencies without the creation of a new legal entity, while the PSS provider holds the focal position of such service ecosystem and acts a system integrator (included in P10, P11). The initial research conceptual model was then reshaped and the research propositions were included in the final research conceptual model presented in Figure 4.

<INSERT FIGURE 4>

5 Conclusion

Traditional manufacturing firms have moved into the service business to preserve their positions in increasingly competitive environments with the evolution of their business models from a 'pure product' orientation towards an integrated PSS. Despite some successful stories, many manufacturing firms have struggled to survive in the service domain. In fact, the servitisation journey involves several challenges.

The goal of this paper was to comprehend how manufacturing firms could positively provide PSS offerings to their customers by examining how the features of such offerings affect the design and management of their upstream supply chains. Therefore, an empirical investigation was conducted using multiple case studies that led to a more comprehensive understanding. First, capabilities emerged as a crucial element to bridge the distinctive levels of PSS value proposition with different configurations of PSS supply chain design and management. Specifically, when moving from product-based to servitised offerings, the required capabilities change from technical to become consultancy- and business-related. This evolution involves a change in the PSS supply chain design and management through establishing partnerships with external companies from different value chains. Moreover, the relationships between partners change from vertical to horizontal as product-oriented solutions move towards process-oriented solutions. Finally, the institution of a distinct business unit that acts as a system integrator towards both internal functions (particularly sales and marketing) and external partners is a vital step on the path to becoming a PSS provider.

The developed model and the final propositions can also help managers and practitioners understand the challenges associated with delivering value through a PSS solution. First, it can be used as a supporting method to describe and compare existing PSS offerings and supply chain configurations by considering the relevant variables included in the model. It can also be intended as a design tool to enhance the (re)-engineering and modelling of the PSS supply chain structure where each partner focuses on its own core competences and where the PSS provider is the focal position and acts as a system integrator. Finally, the model supports managers to assess the consistency of the interfaces between the PSS offerings and the PSS supply chain, making informed strategic decisions, such as "make or buy" choices about required competences for PSS design and management.

Future research could help to overcome the limitations of this work. First, additional case studies should be conducted on result-oriented PSSs that represent the highest servitisation levels of an offering, as soon as they become available in the automotive sector. Furthermore, the model should be tested by means of statistical methodologies to assess its significance, validity and reliability. Moreover, the empirical survey could be carried out in different industries to ensure inter-sector generalisability and to analyse commonalities and differences between diverse manufacturing sectors. Another significant area of research is the influence of servitisation on the customer-PSS provider interface and on the sustainable value created (economic, environmental and social). Lastly, the elements that support (or hinder) the servitisation of manufacturing companies deserve further investigation. Special should be given to digital

technology, which is recognised as a facilitator of service innovation because it enables the transformation of the PS supply chains (Vendrell-Herrero et al., 2015) but still lack appreciation (Lightfoot et al. 2013).

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Appendix

Table 2. Truco within-case analysis.

	PSS supply chain design		PSS supply chain management	
	<i>External partners</i>	<i>Internal departments</i>	<i>Inter-organisational relationships</i>	<i>Intra-organisational relationships</i>

<p style="text-align: center;">Repair services</p>	<p>Assistance network acting on the first level as a strategic partner and on the second level as an operational partner.</p> <p>Legal ties: at first-level workshops with the company; at second-level workshops with the first-level workshops.</p>	<p>Customer service business unit (profit centre) that manages franchised workshops for the actual provision of services.</p>	<p>Decision making is centralised in the company. There is a high degree of direct control over the first-level workshops (with the 'excellence programme', including monetary bonuses), and a high degree of indirect control over the second-level workshops (with the 'excellence programme', including monetary bonuses shared with the first level).</p>	<p>-</p>
<p style="text-align: center;">R&M contracts</p>	<p>Sales and assistance networks acting on the first level as strategic partners and on the second level as operational partners. The first level dealers/workshops are legally tied with the company; second level workshops are legally tied with the first level dealers/workshops.</p>	<p>Customer service (profit centre) manages the assistance network workshops for the actual provision of services (delivery of repair and maintenance activities in the vehicle) and is the direct point of contact with customers for vehicle breakdown.</p> <p>Sales and marketing business unit (profit centre) manages the sales network (R&M contract sales) with the support of the customer service business unit for contract design, bidding, pricing and monitoring.</p>	<p>Decision making is centralised in the company. There is a high degree of direct control in the first-level workshops (with the 'excellence programme', including monetary bonuses), and a high degree of indirect control in the second-level workshops (with the 'excellence programme', including monetary bonuses shared with the first level).</p>	<p>There is no formal structure for communication between the two business units.</p>

Telematics	IT seller (transactional partner) for hardware provision. Assistance network (strategic partner) for diagnostic services. Legal ties are the same of repair services.	Engineering department (previously an external partner that merged with the engineering department) for software design and development. Customer service business unit for data analysis and sale of telematics to the network.	Decision making is centralised in the company. There is a high degree of direct control in the first-level workshops, and a high degree of indirect control in the second-level workshops.	Feedback data from teleservices is exchanged between the quality and engineering departments.
Road Assistance	Assistance network (all the workshops in the first level and some in the second level).	Customer service business unit (profit centre) for assistance network management. In particular, the customer centre sub-unit (cost centre) acts as a direct point of contact with customers for vehicle breakdown and provide coordination with the assistance network.	Decision making is centralised in the company. There is a high degree of direct control in the first-level workshops (with the 'excellence programme', including monetary bonuses), and a high degree of indirect control in the second-level workshops (with the 'excellence programme', including monetary bonuses shared with the first level).	Constant information flow between the two business units. Feedback to the quality department
Training	Training school (strategic partner belonging to the same corporate group) for training delivery.	Service sub-unit of the Customer Service Business Unit for the definition of course content.	Decision making is centralised in the company. There is a high degree of direct control in the first-level workshops, and a high degree of indirect control in the second-level workshops.	Communication with the entire customer service business unit.

Fleet management	Fleet management service provider (potential strategic partner) and Sales Network (for service sales).	Customer Service Business Unit offers development and data collection. Sales & Marketing Business Unit manages dealers for selling the solution and customer's data analysis. Engineering department develops hardware and software.	Decision making is decentralised towards external partners, with a medium degree of indirect control from the company (through information provided by the dealers).	Data flow from the customer to the sales and marketing department, from the sales and marketing department to the engineering department and to customer service business unit.
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Table 3. Tenco within-case analysis.

	PSS supply chain design		PSS supply chain management	
	<i>External partners</i>	<i>Internal departments</i>	<i>Inter-organisational relationships</i>	<i>Intra-organisational relationships</i>
Repair services	Assistance network composed of private capital (17) and wholly owned (51) dealers, acting as strategic partners for the provision of repair services.	After-sales department (profit centre) manages the assistance network.	Decision making is centralised in the company. There is a high degree of direct control in the workshops, including monetary bonuses related to a set of technical KPIs (including first time pass rate, roadside assistance and preventive maintenance inspection).	-
R&M contracts	Assistance network composed by private capital (17) and wholly owned (51) dealers, acting as strategic partners, for the actual provision of the repair services.	Sales function (profit centre) for selling the contracts (salesmen are employed directly by Tenco). After-Sales function (profit centre) for managing the assistance network.	Decision making is centralised in the company. There is a high degree of direct control in the workshops, including monetary bonuses related to a set of technical KPIs (first time pass rate, roadside assistance and preventive maintenance inspection).	Loose relationships between after-sales and sales departments.

Fleet management	Provider of transport management solutions.	Sales function (profit centre) for selling the service (salesmen are employed directly by Tenco). After-Sales function (profit centre) for managing the relationship with the external partner and the analysis of customer's data for new business development (training course).	Decision making is decentralised, with a low degree of control over the external partner.	Loose relationships between after-sales and sales functions.
Contract Hire	Assistance network for repair and maintenance service provision. Financial service provider is a company of the Tenco group.	Sales function (profit centre) for selling contracts (salesmen are employed directly by Tenco). After-sales department (profit centre) for managing the assistance network. Even if the financial service provider is an external company (included in the Tenco group), it is considered as an internal business unit.	Decision making is centralised in the company. There is a high degree of direct control in the assistance network workshops, including monetary bonuses related to a set of technical KPIs (first time pass rate, roadside assistance and preventive maintenance inspection). Low direct control over the financial service provider.	Close relationships between after-sales and sales functions.

Table 4. Carco within-case analysis.

	PSS supply chain design		PSS supply chain management	
	<i>External partners</i>	<i>Internal departments</i>	<i>Inter-organisational relationships</i>	<i>Intra-organisational relationships</i>

Financial leasing	Sale network (dealers with franchisee contracts) and financial service provider. Both are strategic partners.	Sales function (profit centre) for managing the sale network (dealers).	Decision making is centralised in the company for sale and assistance network, with a high degree of direct control, including bonuses for sales representatives based on the number of contacts sold.	-
Long term renting	Sale network (dealers). Assistance network (workshops with franchisee contracts). Financial service provider belonging to Carco corporate group. Petrol company with no legal ties (fuel card is the inclusion of fuel consumption in the monthly fee). External insurance company for insurance service with no legal ties. All the partners are recognised as strategic.	Sales department (profit centre) for managing the sale network (dealers). After-sales department (profit centre) for managing the assistance network (workshops) and the external partner.	Decision making is centralised in the company for sale and assistance network, with a high degree of direct control, including bonuses for salesmen based on the number of contacts sold, as well as bonuses for dealers in accordance with the number of spare parts sold and the level of customer satisfaction. Decision making is decentralised for the other external partners with a low level of control.	Close relationships between after-sales and sales departments.

Table 5. Elmoby within-case analysis.

	PSS supply chain design		PSS supply chain management	
	<i>External partners</i>	<i>Internal departments</i>	<i>Inter-organisational relationships</i>	<i>Intra-organisational relationships</i>

<p>Electric mobility</p>	<p>Assistance network of workshops (franchisee contracts). Joint venture between the parent company and a chemical external company. Financial service provider belonging to the same corporate group as Elmoby. Provider of charging service and infrastructure with no legal ties. Strategic partnerships with all the external partners.</p>	<p>Sales and after-sales departments for the development and management of sales and assistance networks (dealers and workshops), acting as 'collector' of competences. The engineering department provides charging service and infrastructure.</p>	<p>Decision making is centralised in the assistance network, with a high degree of direct control. Decision making is decentralised in the other partners with a low degree of direct control.</p>	<p>Coordination of the involved functions through information flows and shared databases (especially customers' data).</p>
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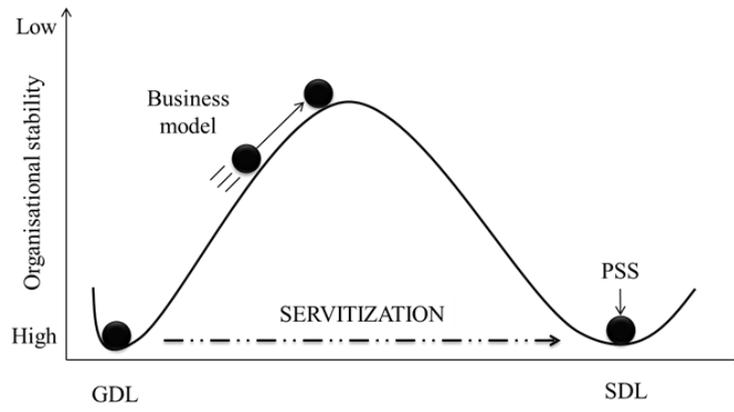


Figure 1. The servitisation phenomenon.

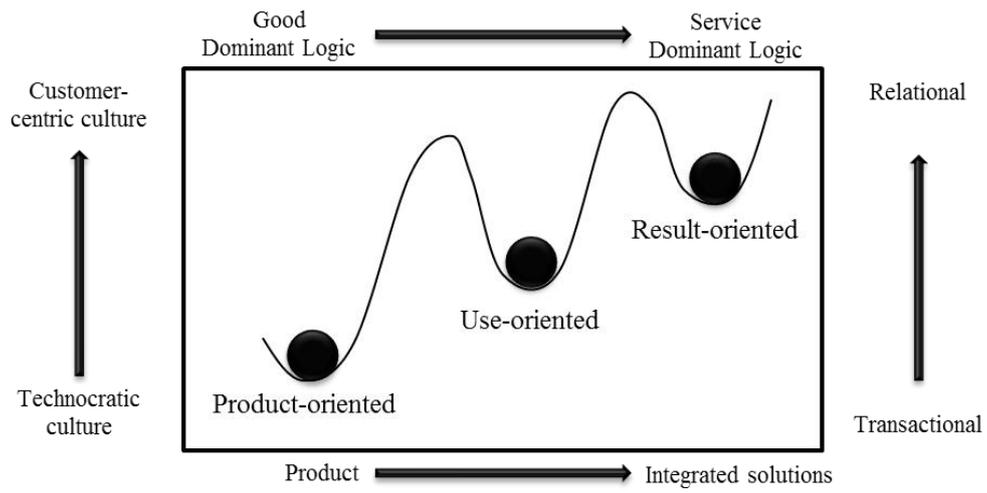


Figure 2. The evolution of servitisation towards the achievement of a new equilibrium.

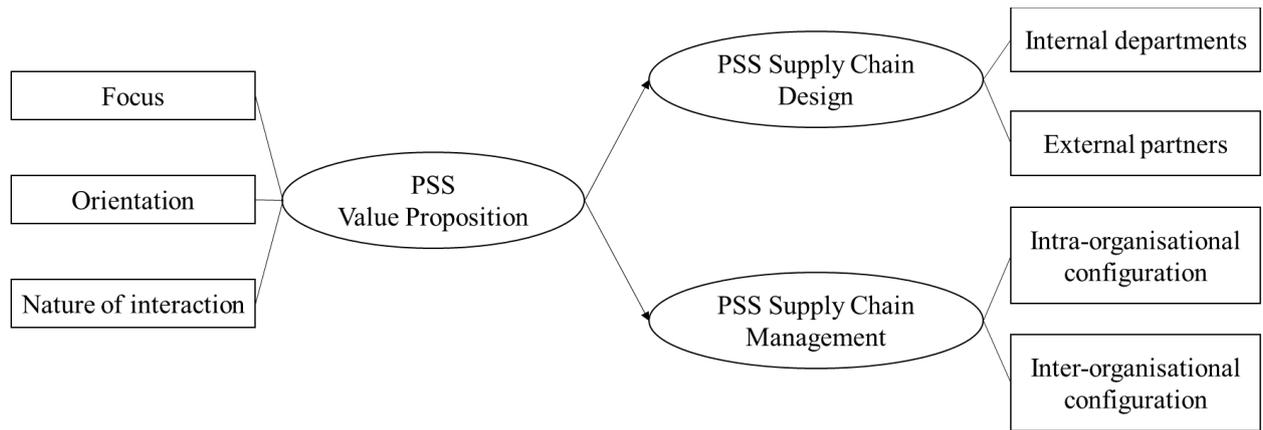


Figure 3. The research conceptual model.

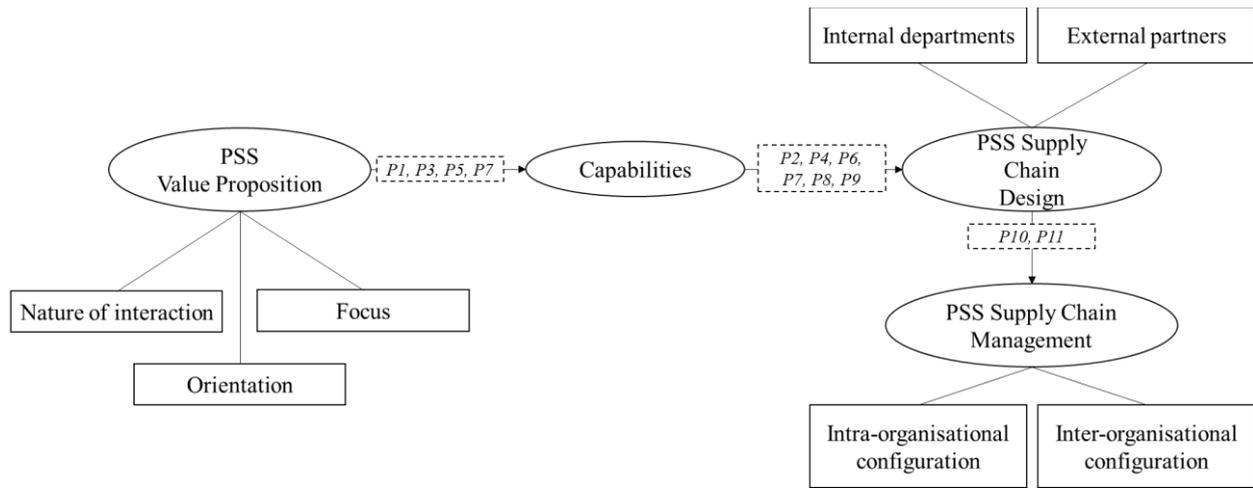


Figure 4. The final research conceptual model.