

A conceptual model for supply chains with customised product-service systems

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Abstract:

The strategic shift towards satisfying customers with customised product-services has intensified over the last decade. However, a formidable challenge emerges in effectively integrating supply chain partners into this service-oriented paradigm. This complexity is compounded by a gap in the literature: a dearth of frameworks that offer a holistic view of these specialized ecosystems. To address this challenge, this paper seeks to elucidate the pivotal elements governing the management of supply chains for customised product-services and to map their interrelationships. Drawing upon an extensive literature review, we propose a novel conceptual model that overcomes the weaknesses of previous approaches by synthesizing these core elements in an integrated manner. Uniquely, the model considers the entire lifecycle of new customised product-services, framed within a collaborative vision among supply chain members. The fundamental elements affecting the management of these supply chains are systematically described. Finally, the paper concludes by proposing some lines for future research directions.

Key words:

Customised product-service systems, supply chain management, conceptual model, mass customization, ICT-Tools.

1. Introduction

Nowadays, companies must make great efforts to be able to build sustainable competitive advantages, as it becomes increasingly challenging to provide products and services that meet customer satisfaction and achieve the desired profitability. It is also widely accepted that competitiveness does not depend exclusively on a company itself, but on the group of companies that collaborate in making the final product-service available to the customer, that is, the supply chain (Wu et al., 2014; Sangari et al., 2015; Gaiardelli et al. (2021)). For this reason, one of the business models increasingly used to boost competitiveness is to offer the customer customised product-service as fast as possible, producing only

those that have a high probability of success and maximising the efforts and the collaboration along the supply chain (Rodríguez et al., 2023). In order to cope with market changes, it is necessary to design products-services that offer value to the customer, rather than just functionalities (Belkadi et al., 2020). The “product-service” concept has different approaches depending on where the focus is placed: on the business model and its strategic orientation; approaching the concept as an integrated system and the value it provides; focusing on the tactical-operational issues of its life cycle, etc. A product-service may be defined as “a shift in business strategy from a product-oriented to a service-oriented focus, where instead of the product itself, the activity, its utility and performance associated with the use of

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the product are considered more valuable to the customer” (Tan et al., 2009). Similarly, there is the “product-service system” (PSS) concept, understood as an integrated product and service offering that delivers value in use (Matsas et al., 2016). This paper uses the latter approach (PSS) to address product-service. Offering PSS is not enough in some markets, and authors such as Haber & Fargnoli (2021) emphasize that PSS has significant potential to offer customised solutions based on current and evolving customer needs. However, one problem is that PSS solutions focused on effectively optimizing supply chain management have received little attention (Fargnoli et al., 2022).

Product-service are becoming more complex and varied, driven by technological advancements and evolving customer needs. Therefore, to address the rapid obsolescence of product-service, adaptable solutions are necessary. Reconfigurable and updatable product-service are those that can have their configurations modified or updated after deployment. Reconfigurable systems are designed to sustain high performance by repeatedly and reversibly altering their configuration to meet various functional requirements or adapt to changing operating conditions (Olewnik et al., 2004). In many instances, product-service reconfigurability is attained by incorporating multiple modes into the product or by creating new services that completely satisfy customers’ needs and expectations (Liu et al., 2015).

As noted by several authors, it is important to consider that there is an increasing trend in manufacturing toward producing highly personalized, often unique products, condensed by the term “mass customization” (Camarinha-Matos et al., 2011). According to Wang et al. (2019), for mass customization to become a viable business strategy, it must create value beyond just offering cost-saving measures to both customers and producers. The shift towards mass customisation requires an improvement of the product durability and personalisation, service reliability, as well as the consideration of technical and functional standards. In particular, customisation of consumer goods is a complex activity, as personalisation depends on numerous requirements: market needs, country standards, customer profiles, design style, etc. (Moncur et al., 2006). However, thanks to Industry 4.0, a new paradigm is being promoted: mass personalization/individualization, which focuses on uniquely made products for individuals at scale (Naldi et al., 2025; Ahleroff et al., 2021).

Finally, another no less important aspect directly related to customised product-service and widely discussed in the literature is co-creation. Co-creation is described as a dynamic and collaborative process involving active participation from both users and manufacturers, with the goal of generating value for customers (Piller et al., 2010). Along the same lines, authors such as Zheng et al. (2019) and Zheng et al., (2019) observe that the focus in manufacturing has transitioned from being manufacturer-centric to customer-centric, involving users actively in the co-creation process to achieve personalized satisfaction. In the co-creation process, online customer communities play a crucial role. These are online networks where people interact socially to share their enthusiasm for particular brands, user experiences, product feedback, retail environments, and consumption activities (Manchanda et al., 2015). This type of community shows great potential for fostering co-creation, being very popular and accessible (Romero and Molina, 2011). Gaiardelli et al. (2021) outline the key directions that could define a future scenario integrating PSS and Industry 4.0. He notes that collaboration among partners and stakeholders drives all participants to engage in diverse value co-creation processes, maintaining a balanced focus on customer-centricity.

Industry 4.0 technologies are widely reported as enablers of mass customization, individualization, and co-creation in supply chains for product-service systems. Several authors (Naldi et al., 2025; Jin et al., 2024; Pech & Vrchota, 2022; Saniuk et al., 2020) have recently commented on the role of digital technologies in enabling flexible, responsive, and customer-centric supply chains. Additive Manufacturing, Internet of Things, Big Data, Cloud, Cyber-Physical Systems, and Artificial Intelligence are the most frequently identified technologies, but only a subset are described as directly enabling customization, with mass customization being the most common approach. The use of cloud platforms and data exchange constitutes an essential pillar for enabling customization and co-design and co-creating processes, thereby facilitating collaboration among geographically dispersed teams (Jin et al., 2024; Pech & Vrchota, 2022). Digital twins (DT) offer the possibility of co-designing, planning, and monitoring manufacturing processes, ensuring the recyclability and disassembly of customized products, thereby reducing resource waste (Jin et al., 2024). To cope with such variety and complexity in on-demand production, it is essential

to have agile and reconfigurable supply chains that can adapt quickly without compromising efficiency or sustainability (Naldi et al., 2025). PSS are increasingly driven by Industry 4.0 technologies forming smart PSS (Bilbao-Ubillos et al., 2024; Gaiardelli et al., 2021).

The purpose of our work is to propose a conceptual model for supply chains dealing with customised product-service. So far, this issue has not been addressed in a comprehensive way, as the existing works in the literature have focused on solving specific problems of this business model, but without a conceptual model that brings together and defines the problem from a global supply chain vision. This approach implies considering the new customised product-service under a collaborative vision, which implies the active participation of the supply chain members in the creation, design, and engineering processes in an environment of equity and trust. To facilitate this approach, it is very useful to use a conceptual model that characterises all the most important elements involved. To bridge this research gap, two research questions have been posed: (RQ1) What are the main elements affecting the management of supply chains with customised product-service? (RQ2) How can these elements be linked to provide a model that helps to define support mechanisms and facilitates the understanding of the above-mentioned issues?

To address these research questions, a literature review is carried out to examine the existing research on supply chains involving customised product-services. To this end, the different definitions, concepts, elements, models and frameworks relating to customised product-service in the supply chain context have been studied. Subsequently, based on the analysis carried out, the conceptual model that is the objective of this work has been developed.

The rest of the work is structured as follows. Section 2 presents the research methodology. Section 3 provides a literature review on the main elements affecting the management of supply chains with customised product-service. Section 4 describes the construction of the conceptual model that provides an integrated vision of supply chains dealing with customised product-service. Lastly, Section 5 outlines the conclusions and suggests directions for future research.

2. Research methodology

In order to accomplish the aim of this work, a constructivist research approach (Kasanen et al., 1993; Coughlan and Coughlan, 2002) has been followed. It consists of addressing problems through the development of procedures or models following a sequence of structured phases, which can be adjusted depending on the type of investigation covered. In this case, the sequence of phases has been as follows:

- a. Find a relevant problem: Making customised product-service available to customers is a complex process involving the supply chain, where multiple elements must be perfectly organised under an integrated and shared vision. For this reason, an effort is made in this work to develop a conceptual model in order to identify, represent and relate these elements, improving the understanding of this type of business model and providing a useful approach for researchers and practitioners.
- b. Obtain a broad and thorough understanding of the topics: The literature on customised product-service has been analysed and the theoretical background on these topics has focused on the supply chain context.
- c. Develop the proposal: Based on the literature review carried out, a conceptual model for supply chains with customised product-service has been developed.
- d. Justify the proposal and its contribution: An explanation of the conceptual model is provided with an explanation of its components, which are in turn linked to the scientific literature.
- e. Describe future research lines: Finally, the discussion section describes the future research lines derived from the work carried out.

3. Literature review

3.1. Overview

Considering the methodology of Seuring and Müller (2008), this paper presents a literature review to discuss the main elements of customised product-service in the supply chain context. The research process involves three steps: (i) establishing the research question; (ii) collecting data; (iii) performing a data analysis. For data collection, two widely accepted databases were used: Web of Science

and Scopus. The search string based on keywords has been: TS=((customised OR customized) AND (“product-service” OR “product service” OR “pss”) AND (“supply chain” OR “network”). Furthermore, a time window between 1990 and 2025 was set to identify the published works, resulting in a total of 72 papers. The article selection process is described in Figure 1.

The selection process was quite strict because the purpose of this work focuses on conceptualizing customized product-service within the supply chain context. Although there are hundreds of works that deal with different aspects of the products-services or product-service system, they often do so without focusing on or covering in detail the problem at an inter-organizational level (supply chain or network). For this reason, only those works that concentrate on this topic and scope have been considered. Table 1 shows the main concepts or elements linked to the papers selected after the literature review.

For instance, Fagnoli et al. (2022) recently used a PSS approach to foster supply chain management optimisation. To do so, they use the Screening Life Cycle Modelling (SLCM) method, a procedure based on the PSS Functional Matrix, and stock management focused on enhancing post-sales services in response to market demand. This approach is supported by a case study in the medical equipment sector, observing the benefits that a PSS solution can provide while also highlighting the necessity for additional research to advance understanding of PSS and supply chain management.

In fact, authors highlight the importance of using PSS business models to obtain customised solutions based on customer needs. Wang et al. (2019) propose

a mathematical online community-based dynamic customisation model, addressing the trade-off between customer satisfaction and enterprise profit. The model, based on a genetic algorithm, helps to decide on such essential aspects such as pricing strategy, the cooperation mode with manufacturers and the degree of customisation. Moreover, it highlights the importance of overcoming the traditional customisation mode by combining the online customer community with mass customisation to effectively match demand with supply. Although the model does not specifically address the global supply chain context, it does take into account aspects such as co-creation, product design, and uses variables like collaboration costs.

In the same vein, Cavalieri et al. (2013) emphasize the importance, among other aspects, of analysing supply chain relationships to establish the extent of collaboration among companies, as well as their level of interactions and coordination. They suggest a cooperative solution platform for designing, evaluating, and implementing technology-driven business models, oriented toward the manufacturing and delivery of customised product-service in global markets. This collaborative platform offers an IT environment that facilitates cooperation between the focal actor and the different stakeholders, supported by two tools: a Business Model Framework and a Business Model Generation Process. Mert et al., (2016) designed an PSS approach that facilitates innovative services for the entire value chain, aiming to achieve better-customised business models.

Likewise, Carneiro et al., (2014) argue that to achieve long-term profitability and sustainability with complex and customised products, the alternative of establishing non-hierarchical business networks

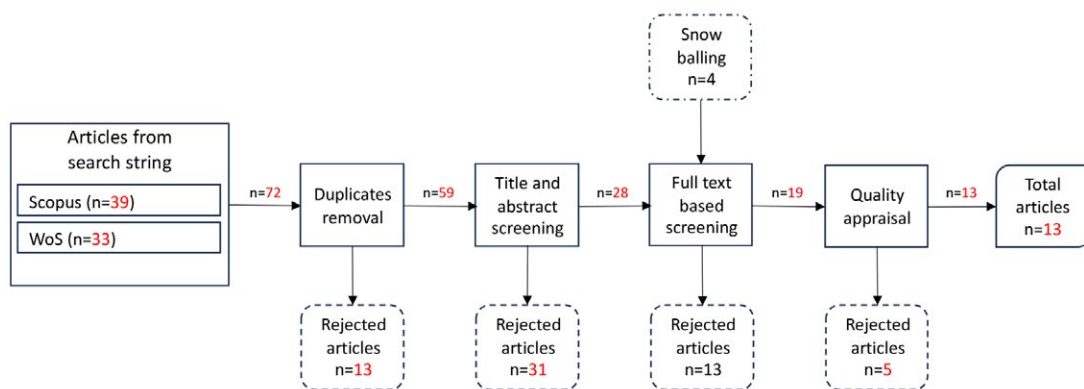


Figure 1. Article selection process.

allowing SMEs to merge their efforts and resources can be used. They have developed a reference model for the collaboration process to address the operational aspects of collaboration projects established to make customized products available to customers. With their model they try to avoid scenarios where added value is minimal and price competition is a priority. Continuous and active collaboration between value network partners is an essential factor in achieving customized solutions (Rasouli et al., 2015). To this end, these authors suggest a shift from a “Conventional Supply Chain” towards a “Service-Oriented Demand-Supply Chain”, under which the focus is on the co-creation of a customer-centric value in the form of integrated solutions through a dynamic networked business. For this purpose, they define a set of adaptive capabilities to enhance the routines within a networked business, especially regarding value co-creation.

Meanwhile, Li et al. (2016) focus on the evaluation of PSS business models, as they consider that there was no comprehensive method in the literature to evaluate them quantitatively.

Over a decade ago, Camarinha-Matos et al. (2011) has already commented that developing customised products and services requires new organisational structures, which involve the supply chain in a process of co-creation. They proposed “an approach based on cloud-computing and advanced collaboration spaces”, which takes into account several interconnected concepts associated with three areas: governance models, organisational structures, and the technological platform (cloud-based). Rizvi et al. (2019) proposed a method for

designing product-service systems by merging the principles of “actor-network theory, service-dominant logic, and value co-creation”. This method is based on four stages: problematisation, interessement, enrollment, and mobilisation. More recently Jin et al. (2024) proposed a quantitative method for assessing the sustainability of Product-Service Systems (PSS) in the context of Industry 5.0, which is characterized by mass customization and a focus on people, sustainability, and resilience.

On the other hand, the relevance of using ICT-based tools in the collaborative processes to provide customised products is also highlighted by Shamsuzzoha et al. (2016). They seek to facilitate the collaboration of SMEs to improve the design and manufacturing of customised products.

To this end, they have developed an ICT platform, through web and Internet of Things technologies.

3.2. Elements affecting the management of supply chains with customised product-service

After this brief literature review, the gap that is the object of this work can be reaffirmed, namely the absence of a conceptual model that brings together in an integrated way all the elements that affect the development of customised product-service in the supply chain context. In this regard, the first step is to obtain these elements (Figure 2), which are deduced from the analysis of the works previously described and reflected in Table 1. These are outlined below.

Table 1. Literature review synthesis.

Author	Product-service design	Business model design	ICT-based tools	Mass customisation	Co-creation
Jin et al., 2024	✓		✓	✓	
Fagnoli et al. (2022)		✓			
Wang et al. (2019)	✓			✓	✓
Rizvi et al. (2019)	✓				✓
Dehn et al. (2018)	✓				✓
Shamsuzzoha et al. (2016)	✓		✓		
Li et al. (2016)	✓	✓			
Mert et al. (2016)		✓			
Rasouli et al. (2015)		✓		✓	✓
Carneiro et al. (2014)			✓		
Cavalieri et al. (2013)	✓	✓	✓		
Vandaele and Decouttere (2013)	✓	✓		✓	✓
Camarinha-Matos et al. (2011)	✓	✓	✓	✓	✓

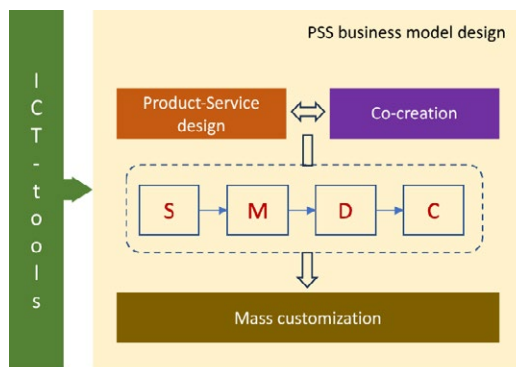


Figure 2. Elements affecting the management of SCs.

I) Product-service design: The value proposition of a PSS lies with the actors that make up its supply chain (He et al., 2016), so the participation of these actors in the PSS design is important. This same orientation is followed, among others, by Rodriguez et al. (2023), highlighting that the design process should be considered as a result of relationships and shared knowledge of the network. Besides, given the growing demand for customized products and evolving customer trends, designing a PSS will require considering the changing environment (Chang et al., 2018). The literature shows the multidimensional, multidisciplinary and multiscale nature of services, products and processes design (Power and Jansson, 2008). The emerging PSS paradigm demands novel design approaches and supportive tools (Doultsinou et al., 2009). Authors such as Jin et al., (2024) emphasize that decisions about the design of PSS involve determining their level of sustainability.

Despite numerous studies on product-service systems, opportunities still exist to improve the design methods so that they can provide different content in response to changing needs (Chang et al., 2018). Along the same line, Dehn et al. (2018) and Rizvi et al. (2019) comment that the method of designing a PSS is little explored. Given that the participation of suppliers, manufacturers, distributors, and other specialised actors is necessary in the product-service design process, mechanisms must be established to facilitate information exchange and the integration of ideas to cover the needs of customers. On the other hand, most of the previous researches on PSS design are focused on satisfying customers, without considering customisation (Chang et al., 2018). It should be noted that in many cases the product design

affects the process design, that is, the process that helps to adapt the material (facilities, machines, technology, tools, spaces, etc.) and human resources to the mass customisation of the product-service. This adaptation usually affects directly or indirectly all the partners in the supply chain, which implies analysing in detail the consequences that the design phase will have on business processes. Thus, the design process should be considered as a result of the relationships and shared knowledge of the network (Rodriguez et al., 2023). Although there is a range of models and methodologies for designing product-service, a comprehensive methodology, as well as the existence of feedback loops among the different life-cycle phases, is still missing (Wang, 2019).

II) PSS business model design: A business model is a “system of interconnected and interdependent activities that determines the way the company does business with its customers, partners and vendors” (Amit and Zott, 2012), helping to explain how a business creates and delivers value to customers (Baden-Fuller and Morgan, 2010). It is not easy for companies to offer PSS solutions due to internal difficulties in successfully designing and implementing PSS business models (Reim et al., 2015). Moreover, the frameworks developed (e.g. Cavalieri et al., 2013; Ferreira et al., 2013; Kindström and Kowalkowski, 2014) need to better detail the variables that characterise the components of such business models (Adrodegari and Saccani, 2017). However, the implementation of the PSS business model has garnered interest from both practitioners and academics, although there is a noticeable shortage of studies focusing on the practical implementation of these models that consider not only manufacturing issues but also supply chain features (Fagnoli et al., 2022; Mert, et al, 2016). In this sense, for Li et al. (2016) assessing the value delivery of PSS business models is crucial. Related to the business model design focused on mass customisation, Vandaele and Decouttere. (2013) observed that new companies implementing the mass customization business model are more likely to succeed compared to established companies transitioning to mass customization. Therefore, PSS business model design must be given special attention to ensure the feasibility and sustainability of the PSS, considering a supply chain perspective, or, in other words, all the members of the value chain.

III) ICT-based tools: Providing customised product-service implies that the supply chain members collaborate in all the phases of their life cycle. The widespread use of ICT-based tools that support the generation, development, manufacturing, distribution, monitoring and control processes of such product-service makes this element essential. Multiple authors have highlighted the importance of ICT-based tools or platforms to address collaborative processes, business networks or collaborative solutions to facilitate mass customisation (Barczak et al., 2007; Chituc et al., 2009; Iskanius et al., 2009; Carneiro et al., 2010; Camarinha-Matos et al., 2011; Afsarmanesh & Thamburaj, 2012; Cavalieri et al., 2013; Carneiro et al., 2014; Shamsuzzoha et al., 2016; Gaiardelli et al. 2021; Jin et al., 2024). Another essential aspect that must be covered by ICT-based tools is the exchange of information and knowledge (Carneiro et al., 2014) inside the network or supply chain. Thus, the integration of applications must be reviewed, seeking common solutions that are easy to implement.

IV) Mass customization: This element is considered essential to adapt the specific characteristics of the products to the needs of each individual client. To do this, it is necessary to involve the customer into the product design. From a strategic management perspective, mass customisation is a differentiated strategy (Camarinha-Matos et al., 2011). One of the main problems for companies investing in mass customisation is facing the challenges of a “low sales conversion rate” (Wang et al., 2019). The shift towards mass customisation requires an improvement of the product durability and personalisation, service reliability, and the consideration of technical and functional standards. Vandaele and Decouttere (2013) commented on the importance of considering, in an integrated way, three aspects of mass customisation from a design perspective: the product, process and supply chain. For them, companies applying the mass customisation business model must find the best possible cost-benefit trade-off of the unique product-service while seeking good supply chain performance. Although in the literature there are many works using different approaches to improve the performance of companies that use mass customisation as a competitive strategy (Bonev et al., 2015; Viana et al., 2017; Galizia et al.,

2019; Zennaro et al., 2019; Wang et al., 2019; Jin et al., 2024; etc.), practically none of the approaches used provide a multi-stakeholder vision of the supply chain as a dimension that must be addressed for a global approach.

V) Co-creation: The common denominator used by different authors to refer to co-creation lies in understanding it as a process in which both manufacturers and clients collaborate, trying to generate new useful value for the latter, and consequently for the manufacturers as well (Piller et al., 2010; Gummesson et al., 2014). For Camarinha-Matos et al. (2011), delivering customised and service-enhanced products demands new organizational structures to carry out a co-creation process involving suppliers, manufacturers and customers. In summary, these authors highlight the significance of engaging the global supply chain in the co-creation process, which, evidently, must be reflected in the actions of the supply chain management itself. On the other hand, authors such as (Vandaele and Decouttere, 2013) emphasise the importance of balancing the company’s identity and brand essence in customised products and services, with offering guidance during the co-creation process, as customers expect. To help the co-creation process, several authors use online customer communities, since, among other things, this tool facilitates customer participation in the co-creation process, enhance their purchasing intention, and ultimately, increase brand loyalty (Wang et al., 2019). Rasouli et al., (2015) define several dynamic capabilities for value co-creation of a networked business, two of them stand out, on the one hand “the partnering agility”, reflecting the capability of a networked business to create a flexible coalition of resources to facilitate value co-creation processes, and on the other, the “strategic foresight”, reflecting the capability to predict a customer’s anticipated experience with a product or service.

Once the elements that affect the development of customised product-service in the supply chain context have been briefly described, the next section focuses on developing the conceptual model that integrates these elements and takes into account the particularities of the customised product-service.

4. Development of a conceptual model for supply chains with customised product-service

4.1. Background

A conceptual model can be defined as “a set of concepts used to represent or describe an event, object or process, and can be based on the integration of different works into the same subject” (Mundi et al., 2019). Moreover, it outlines the key features that must be taken into account and their expected interactions (Resta et al., 2017). Prior to describing the conceptual model developed in this work, a literature review was conducted to identify possible conceptual models or frameworks that directly or indirectly address the topic presented above. Although several models/frameworks were identified, only the two most comprehensive and detailed were selected as the foundation for developing the conceptual model proposed herein. The two models are as follows:

(i) Supply chain model for product-service systems (Xu et al., 2014). Authors present a model focused on three core elements: functional process management, value co-creation and the enabling process management. Value co-

creation demands recognizing, understanding, and fulfilling the value propositions of all stakeholders. Depending on its role in direct service provision, the process is divided into two categories: “functional process” and “enabling process”. The former is closely related to value realization for customers and other stakeholders, whereas the latter provides the technological and managerial support necessary for other activities, including performance management and customer relationship management. Some limitations can be identified in this model. On the one hand, as the authors themselves acknowledge, it is not designed to be applied to consumer goods, and on the other hand, the relationships among its three core elements are insufficiently detailed. Furthermore, the model does not address the issue of customised product-service systems.

(ii) Conceptual model to link the value proposition and supply chain of product-service system providers (Resta et al., 2017). In this model, the PSS provider is positioned as the central actor, integrating other partners who contribute value while focusing on their core competencies. This model aims to improve

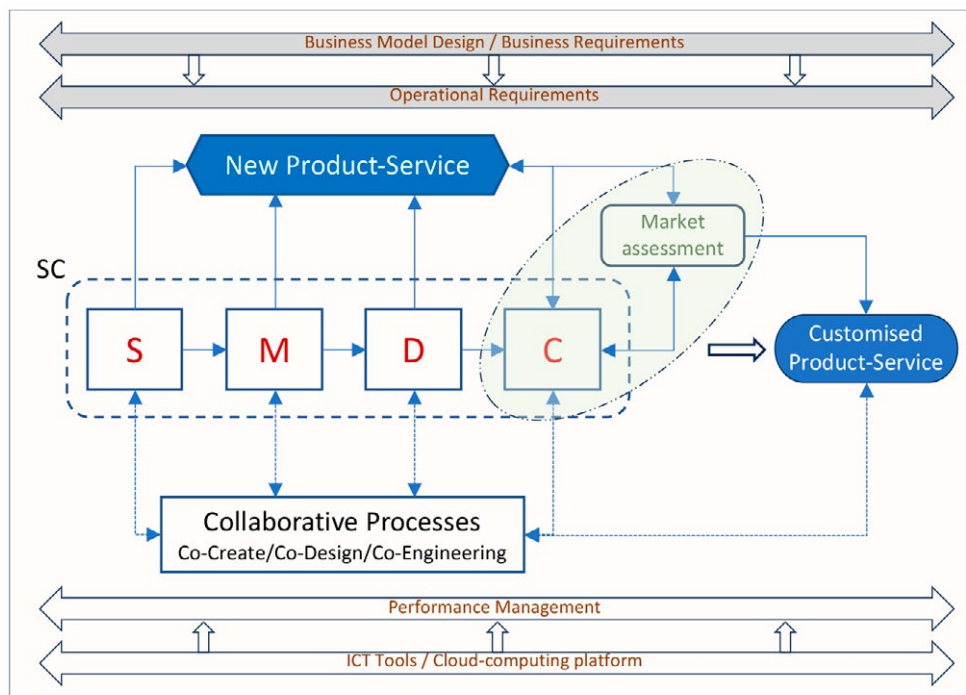


Figure 3. INNOPROS conceptual model.

the structure of the supply chain by facilitating its modeling. The model is grounded in a set of constructs and variables. The “PSS value proposition”, characterized by three variables (orientation, focus and nature); the “capabilities” which encompass the skills and competences required to develop the PSS value proposition, whether internal or external to the focal company and/or supply chain; The “PSS supply chain design,” which outlines the architecture of the supply chain by detailing the internal structure and external actors involved in co-creating and delivering PSS value propositions; and finally, the “PSS supply chain management”, which establishes the connections between the elements of the PSS supply chain and is distinguished into intra-organizational and inter-organizational levels. Among its main limitations are the lack of orientation towards customised PSS, since it was not conceived for that purpose, and the absence of ICT-based tools that could facilitate collaboration mechanisms among all supply chain partners.

4.2. Conceptual model for supply chains with customised product-service

A conceptual model called INNOPROS (Innovative Products-Services) has been developed to address supply chains that employ the launch of personalised products and services as a business strategy. This model seeks to synthesize the elements and concepts derived from the preceding literature analysis while simultaneously mitigating the weaknesses identified in previously discussed models. To this end, all the elements and concepts have been integrated following a kaleidoscopic approach. The INNOPROS conceptual model (Figure 3) comprises two primary constructs: processes and elements. Regarding processes construct, a distinction is made between key processes (Business model design; Operational requirements; Collaborative processes and Market assessment) and support processes (Performance management and ICT tools). The element construct, in turn, consists of the new product-service and the customised product-service.

The central axis of the model is formed by the partners constituting the supply chain network, including Suppliers, Manufacturer, Distributors, and Customers. Therefore, both the processes and elements are designed to address the needs of all stakeholders, thereby forming a management

structure essential for navigating the complexities of successfully launching a product-service on the market.

Next, a detailed description of each construct within the INNOPROS conceptual model is provided:

- **New product-service:** This element refers to the novel product-service intended for market launch. Initially, it exists as a concept that requires validation before its transformation into a customised product-service. Furthermore, this initial concept is not exclusively originated by the manufacturing or focal company; rather, it can emerge from any partner within the supply chain. Consequently, well-established supply chains, founded on principles of trust and equity, exhibit a higher propensity for launching new product-service.
- **Business model design:** This process defines the framework through which the supply chain is structured and organized to generate customer value via a customised product-service. It is a critical process for ensuring that the actions undertaken by partners converge efficiently, providing all stakeholders with a lucid understanding of their respective roles and their contribution to value creation. The significance of this key process has been highlighted by numerous authors (Amit and Zott, 2012; Vandaele and Decouttere, 2013; Xu et al., 2014; Mert et al., 2016; Adrodegari and Saccani, 2017; etc.) as one of the essentials determinants in the success of product-service.

Following the establishment of the business model design, business requirements are meticulously defined. This definition pertains particularly to both the structural organisation (which involves delineating the relationships between supply chain partners and their roles within the value chain, thereby establishing the structures, processes, and regulations that govern collaboration) and the cultural framework (which focuses on cultivating an organisational culture conducive to adopting generated knowledge, fostered by a receptiveness to internal/external changes and social collaboration).

- **Operational requirements:** This process involves the definition of operational requirements that stem from the previously established business requirements. Specifically, it encompasses the allocation of physical and tangible assets, including human resources, tools, equipment,

facilities, etc. This process is tasked with furnishing supply chain partners with the necessary resources to operate throughout the entire product-service lifecycle; hence, it must be inherently dynamic.

- Collaborative processes: This construct encompasses the interrelated processes of co-creation, co-design and co-engineering. These collaborative processes are executed within a framework of partnership across the supply chain. During the co-creation process, value is generated for the client in alignment with the previously established business model. Initially, the ideas from which new product-service emerge are simply a set of notions, thoughts, opinions and sketches that must be analysed following a multi-partner vision, trying to assess the added value they may have. Authors such as [Camarinha-Matos et al. \(2011\)](#), [Harrington and Srai \(2012\)](#), [Vandaele and Decouttere \(2013\)](#), and [Wang et al. \(2019\)](#) emphasise this process, among others. Subsequently, the product-service co-design process utilizes the output from the co-creation phase to develop a creative and innovative design that is mutually agreed upon by all partners (style, shapes, dimensions, materials, uses, complementary services, etc.). This is achieved through specific methods and methodologies designed not only to facilitate information exchange but also to foster a successful outcome. Upon validation of the design, the co-engineering process then determines the most feasible manufacturing methods, taking into consideration the specifications derived from the co-design process. Consistent with the preceding processes, active partner participation is expected to reduce manufacturing lead times, as potential impediments are identified and addressed from the outset. The outcome of this phase is one or more product-service prototypes, which then proceed to the market assessment process for evaluation.
- Market assessment: Following the product-service prototypes, their market acceptance must be rigorously evaluated. This evaluation informs the necessary iterative cycles required to incorporate any deemed essential customisations. Contemporary tools leveraging artificial intelligence algorithms are capable of predicting the success level of a customised product-service by analyzing customer feedback collected from social networks. Furthermore, this process serves to validate the strategic decision to implement mass customization, particularly concerning aspects centered on the customer and their perception of added value.
- Performance management: This support process is defined as “the set of methods, processes, structures and behavior of the partners used in an organization to improve performance” ([Roth, 2003](#)). In this case, this concept is applied to the entire supply chain. Its scope extends beyond managing the final performance of the customised product-service to encompass all constituent processes of the INNOPROS conceptual model. Consequently, monitoring and control are implemented throughout all phases: prior to, during, and subsequent to the market launch of the product-service.
- ICT tools: The effective management of information and knowledge flows within a supply chain necessitates the use of Information and Communication Technology (ICT) tools. This process is focused on integrating the digital infrastructure and software to facilitate seamless information exchange among all partners and to provide support for the other model processes. For over two decades, numerous authors have been highlighting the relevance of ICT-based tools in the network context or supply chains that manage customised product-service ([Camarinha-Matos et al., 2011](#); [Carneiro et al., 2014](#); [Shamsuzzoha et al., 2016](#), etc.). Among these cloud technology is an increasingly prominent solution, as it helps to manage and enhance the areas of product design, engineering, manufacturing processes, etc. by providing a globally optimised solution ([Wang et al., 2013](#)). Therefore, it can be asserted that the adoption of cloud computing will have a positive impact on both supply chain integration ([Novais et al., 2019](#)) and supply chain operational performance ([Bruque-Cámara et al., 2016](#)).
- Customised product-service: This final element represents the outcome following a positive validation from the market assessment process, inclusive of any iterations for mass customisation. In this context, it is imperative to strike a balance between unique product-service performance and its associated cost. This involves maintaining the complexity of collaborative processes within manageable

limits while simultaneously addressing the challenges posed by potentially low sales volumes.

5. Conclusion

“PSS has been acknowledged as one of the most encouraging and promising industrial applications aiming for profit and competitive advantages in manufacturing industries” (Xu et al., 2014). However, using PSS as a strategy to attract new customers and markets in an efficient way for the supply chain involved in such a strategy is a major challenge. Several authors have pointed out the lack of models or frameworks that focus specifically on PSS solutions in a holistic view of the supply chain (Haber & Fagnoli, 2021; Fagnoli et al., 2022; Rodriguez et al., 2023).

The purpose of this work has been to develop a conceptual model for supply chains dealing with customised product-service. Two research questions were answered:

- RQ1) What are the main elements affecting the management of supply chains with customised product-service? After a literature review, five key elements were identified: Product-service design, PSS business model design, ICT-based tools, Mass customisation, and Co-creation.
- RQ2) How can these elements be linked to provide a model that helps to define support mechanisms and facilitates the understanding of the above-mentioned issues? In order to answer this research question, those works that had a direct relationship with the topic addressed were also analysed. Two papers were found (Xu et al., 2014; Resta et al., 2017) that serve as a basis for the construction of a conceptual model called INNOPROS. This model attempts to reduce the weaknesses of the previous models by putting together all the elements and concepts in an integrated way and following a kaleidoscopic approach. It contains two types of constructs: processes and elements. Regarding processes, two types are distinguished: key processes, understood as basic processes,

without which the customised product-service cannot be developed, and support processes, which directly support the operation of the key processes and facilitate their management. As for the elements, there is the new product-service and Customised product-service.

The INNOPROS conceptual model is considered to help managers and practitioners, providing them with an overview of the processes required to undertake customised PSS under a supply chain approach. It establishes the relationship between all processes and elements and facilitates partners' understanding of these processes.

Future research should be carried out to complete the operability of the model. On the one hand, the model should be contrasted with various supply chains belonging to different sectors, considering whether the structure conceived in the model reflects the complexity of their specific sector, and if so, to complete, modify or extend it accordingly. On the other hand, a methodology should be developed that helps practitioners to deploy all the key and support processes, establishing the order of execution and the detailed interrelation of the activities that comprise them. In this regard, considering the importance of ICT tools not only as support processes but also as an essential part of co-creation, co-design, co-engineering, etc., it is necessary to delve deeper into the development of AI algorithms that help optimize product-service customization, balancing costs for supply chain partners and value for the customer. Finally, it is also necessary to consider and analyze the capacity of the INNOPROS model to encompass a circular economy and sustainability approach. Currently, the authors of this paper are working on all of the above-mentioned lines.

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