

Article

Digital Product–Service Innovation and Sustainability: A Multiple-Case Study in the Capital Goods Industry

Alberto de la Calle ^{1,*} , Inmaculada Freije ² and Aitor Oyarbide ¹ 

¹ Industrial Management Department, University of Deusto, Avda. de las Universidades, 24, 48007 Bilbao, Spain; aitor.oyarbide@deusto.es

² Strategy and Information Systems Department, Deusto Business School, Hermanos Aguirre, 2, 48014 Bilbao, Spain; ifreije@deusto.es

* Correspondence: acalle@deusto.es

Abstract: Digitalisation, servitisation, and sustainability are keywords for the current and future development of the manufacturing industry. However, their interaction in the context of an organisation and its supply chain is unclear. This study examines how digital product–service innovation (PSI) or digital servitisation affects sustainability, considering the triple bottom line perspective, as well as identifies the underlying causes. Moreover, this study analyses the role played by supply-chain strategic collaboration, both internal and external to the company, in digital PSI and sustainability. Using a multiple-case study methodology and B2B market perspective, four companies belonging to the capital goods industry were analysed. Our findings indicate that digitalisation is leveraging both basic and advanced services in their impact on economic and environmental sustainability dimensions, while the results are limited in social sustainability. In addition, supply-chain integration is relevant for digital PSI. Internal integration is required for both basic and advanced services, while external integration is especially important in advanced services. We conclude by emphasising that companies should acquire digital capabilities to develop defensive and offensive business strategies that ultimately affect sustainability.

Keywords: digital product–service innovation; product–service system; PSS; sustainability; supply-chain integration; triple bottom line; case study; basic services; advanced services; digital services



Citation: de la Calle, A.; Freije, I.; Oyarbide, A. Digital Product–Service Innovation and Sustainability: A Multiple-Case Study in the Capital Goods Industry. *Sustainability* **2021**, *13*, 6342. <https://doi.org/10.3390/su13116342>

Academic Editor: Marco Opazo Basáez

Received: 26 April 2021
Accepted: 30 May 2021
Published: 3 June 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Scholars, policymakers, and practitioners have considered services as a method for addressing the aggressive cost competition faced by many manufacturing firms in mature markets. However, from an environmental perspective, there is a huge potential for industry transformation, especially associated with changes in business models, by offering performance-based product–service systems (PSS) such that, by shifting ownership from customer to supplier, PSS maximises the incentive to optimise efficiency and extend product life [1].

Simultaneously, service and efficiency are improving with the development and generalisation of information and communication technology (ICT). ICT is opening up possibilities for optimisation, customisation, and extension of product life and use [2], thereby generating unprecedented opportunities for product–service innovation (PSI) [3]. Thus, digitalisation becomes an enabler for both PSI and promotion of sustainability, rapidly transforming the competitive landscape for manufacturing companies [4].

However, despite the aforementioned interest and opportunity, some issues still need to be addressed. First, when transitioning to PSI, in addition to internal coordination, supply-chain collaboration is necessary. In fact, supply-chain integration (SCI) is an enabler for adding value to products and services [5]. Matthyssens and Vandenbempt [6] highlighted the demerits of studying value creation by individual suppliers in isolation, mainly in business markets. Nevertheless, the number of studies that explore SCI in all

its dimensions is limited. Second, considering the increasing awareness, businesses have included environmental and social sustainability, along with the traditional economic sustainability, in their business decisions. Businesses have responded to the new needs by redefining their operations and designing new products and services. In this context, the literature usually relates PSI to environmental sustainability [7,8]. Nevertheless, the PSI literature has largely ignored social sustainability, which, when addressed, reduces the effects on employment.

The three mega-trends in society, digitalisation, sustainability, and servitisation, change the conditions for manufacturers when developing and providing new products and services [9]. In this study, we aim to combine these trends to extend their relationship in terms of digital services against other types of services in the capital goods manufacturing sector. Servitisation is a form of innovation for manufacturing companies that occurs through the incorporation or development of services linked to the product offerings of said companies that may have an important impact on sustainability. In this context, digital technologies offer many possibilities for servitisation. Thus, the present study aims to address the following research question: What opportunities that affect sustainability (in terms of its three strands: economic, environmental, and social) can be generated by digital services?

We address this question by comparing the services offered by four manufacturing companies in the capital goods sector in a multiple-case study. We study how and why they make a significant impact on sustainability by identifying the opportunities of digitalisation on each type of company services. Through this approach, we also analyse the effect of the level of SCI.

This study is presented as follows: Section 2 presents a literature review. Section 3 explains the adopted methodology and justifies its suitability for the research objectives and conditions. Section 4 presents the results and their evaluation in the analysed context. Section 5 presents the conclusions, limitations of the research study, and suggestions for future work.

2. Literature Review

The literature review considers the four key variables of this analysis in relation to PSI or servitisation of manufacturing firms. Firstly, the categorisation of services is considered, followed by digitalisation and SCI as sources of product–service innovation, and lastly the potential of servitisation for sustainability.

2.1. Product–Service Innovation and Service Categorisation

In the late 1980s, Vandermerwe and Rada [10] referred to the “servitisation of business” as companies offering fuller market packages or “bundles” of customer-focused combinations of goods, services, support, self-service, and knowledge, changing the competitive dynamics.

Manufacturing companies face challenges to compete and differentiate their products in most industries. Commoditisation is driving cost competition, thereby placing developed countries in a difficult position. Product design and manufacturing are no longer the main sources of the differentiation and competitive advantage [8]. Servitisation is a suitable approach under such conditions, first, to help manufacturing companies compete and defend their industrial business and, second, to open up new business opportunities, distinct and yet related to the traditional business. In some cases, it is necessary for manufacturing companies to include a warranty for a specific period to comply with the legal requirements or align with the market. In other cases, inclusion or development of services is an important aspect of the manufacturing company’s value proposition through innovation and customer satisfaction [11].

In this vein, Bustinza et al. [12] considered servitisation as a way to extend traditional product innovation models, coining the term product–service innovation, adding more nuances for manufacturing companies. Traditionally, innovation in manufacturing

companies was associated with product innovation, while that in service companies was associated with service innovation. However, traditional boundaries between sector fall and service innovation are a way to introduce something new to develop and maintain firm performance and competitiveness, increasingly used by manufacturing companies [13].

Moreover, services require greater proximity to customers and a consistent long-term relationship, thus increasing the complexity for remote suppliers. However, servitisation can be considered a continuum [14], depending on the extent of the interaction, scope of change, and the number of agents involved in the change. Furthermore, services provide competencies for product innovation by facilitating a better understanding of customer needs, which is another potential source of differentiation [15–17].

In addition, services offer new business opportunities by creating new revenue streams, which, in some cases, have become the main source of income for the company. For example, in the automotive sector, financial services and maintenance, repairs, and extended warranties generate much of their revenues and profits [18]. In some cases, the product itself may be replaced as in the paradigmatic cases of Rolls Royce 'Power by the Hour', where a customer pays by the usage of the engine instead of buying it and contracting maintenance [19] or Michelin's pay-per-kilometre solution [20].

Services add value to products such that they are increasingly integrated into the offer. Consequently, distinguishing between products and services has become more difficult, which has resulted in the emergence of product–service systems (PSS). The traditional boundary between manufacturing and services is becoming increasingly blurred [21].

Although debated among various authors, the PSS concept refers to product(s) and service(s) combined in a system to deliver the required user functionality [22] or fulfil the specific needs of customers [23]. PSS includes various possibilities for manufacturing companies from adding complementary services to the product offering to provide total solutions that make it unnecessary for customers to purchase or own the product. The latter means a shift from being a manufacturing company to becoming a service provider, thereby changing the firm's role in the value-creation process [24]. In these extreme cases, the production of the physical components of the PSS is typically outsourced [25].

Studies have used different approaches to propose taxonomies or categorise services. Mathieu [26] distinguished between service supporting the supplier's product and that supporting the client's action in relation to the supplier's product, thus highlighting the differences in the intensity of the relationship and customisation.

Tukker [27] considered three types of PSS: product-oriented services, where services complement and add value to product use, use-oriented services, where service provides the use of the product instead of the ownership (i.e., leasing), and result-oriented services, where the centre is no longer in the product but in its result. Similarly, Cusumano et al. [19] developed a taxonomy distinguishing, on the one hand, services that complement the company's products, which facilitate its use or sale without altering the product's functionality (smoothing), and those that enhance, expand, or adapt the product's functionality (adapting), and, on the other hand, services that replace the purchase of the product (substituting).

Baines and Lightfoot [28] proposed four service categories: (1) no servitisation; (2) base services: an outcome focused on product provision; (3) intermediate services: an outcome focused on the maintenance of product condition; (4) advanced services: an outcome focused on the capability delivered through product performance.

Brax and Visintin [29] identified eight value constellations ranging from basic type—products with limited support, such as basic maintenance and support services—to the most complex configuration, total solutions, where the supplier operates and owns the system, and the payment is based on output or outcome on a long-term basis. Another interesting approach by the same authors [30] was used by Bustinza et al. [31] to identify the most profitable and solvent configuration of service offerings throughout the product life cycle.

Oliva and Kallenberg [32] combined the orientation to product or to user processes and their transactional or relational nature, which classifies various services.

However, companies simultaneously work with services aligned with various levels of servitisation and integration (e.g., related to the continuum of Martinez et al. [14]). Therefore, this study considers a suitable wider service categorisation. In the literature, despite the focus on the transition from pure products to pure services in manufacturing firms, some studies have emphasised the coexistence of different service levels [33,34].

To achieve a simpler and more accurate understanding of the companies, we examined the taxonomy alongside business terminology. We adopt a variation of Mastrogiacomo et al. [35] who proposed the taxonomy of product-related services and analysed the services provided by more than 8000 Italian medium–large (more than 50 employees) manufacturing companies. They considered nine services categories: (1) consultancy services: advice and assistance related to your expertise; (2) customised product design and development services; (3) retail sales and distribution services (with an articulated organisation to support customer service); (4) financial services: long-term credits related to your products, rental contracts, leasing, etc.; (5) logistic services: the company provides delivery, transport and/or storage services for its customer's products, components, or raw materials; (6) installation and commissioning services: the company installs and tests its products and trains the personnel in charge of their use; (7) management and operation services of its products throughout their life cycle: the customer receives only the benefits of product use without having to execute it; (8) maintenance and support services during the life cycle of the product, offering spare parts; (9) disposal, recycling, or conversion services at the end of the product life cycle.

2.2. Digitalisation and Product–Service Innovation

ICT is opening huge opportunities for PSI [3] by adding value to products, allowing more efficient processes and supporting improved managerial decisions with richer, faster, and sounder information [36]. Digital capabilities are embedded in physical products by reinventing or enhancing products seeking competitive advantages [37]. Digital capabilities also allow different methods to relate to customers, improve access to information and communication, develop customisation opportunities, or strengthen the relationship. Moreover, ICT can open new and diversified business opportunities.

The combination of technologies has enabled the digital revolution ushered by smart products that produce not only abundant information but also new knowledge about the product's behaviour, form, and context of use. Therefore, there exist new and exciting opportunities in terms of efficiency and optimisation, customisation, and the extension of product life and utilisation [38]. Rapidly advancing technologies are creating a promising avenue for upgradability as a form of product-life extension in the context of PSS [39].

Moreover, some studies linked digital technologies to efficient, reliable, and cost-efficient operations for manufacturing companies in the context of servitisation [40]. Consequently, as indicated earlier, digitalisation offers enormous potential both internally, by improving the efficiency of a company, and externally, by expanding the market for said company's offerings and creating new value propositions. The lower cost and deep market penetration of sensors and transmission devices have accelerated the process of digitisation [41]. Product–service data have increased the speed of product innovation [42]. This acceleration can be interpreted as an R&D investment [43]. Smart, connected products improve service and efficiency and allow a fundamental shift from reactive service to preventive, proactive, and remote service [38].

However, according to Lerch and Gotsch [44], there are different stages in the transition from manufacturer to provider of digitalised PSS: (1) the threshold stage, which has no impact on the company's competitive advantages, (2) offering teleservices using ICT solutions, allowing manufacturers to provide faster and/or higher quality services with fewer resource inputs, (3) providing purely digital services, such as software-based simulations, virtual or augmented reality applications, or digital technical analysis, (4) using

digitalised PSS (independent operating systems using ICT solutions as a component in the product-service bundle).

Opazo et al. [40] linked green and digital servitisation with reference to the automotive industry as they coexist and operate jointly, but they warned that, to obtain productivity gains from green servitisation, firms should offer digital services first. Green services are defined as those specifically designed services to enhance digitally sustainable initiatives in both product development and product life cycle.

Considering PSI, the literature warns of the difficulty of understanding the precise capabilities and transformation needed to develop and deliver services [45]. Specifically, digital transformation, although underexplored by many companies, often plays a dominant role [3]. To support digitalisation initiatives, companies must build new capabilities. However, manufacturers, particularly small and medium enterprises (SMEs), find it difficult to access the required resources and competencies [46].

Among these capabilities, digital technology and its efficient use are imperative for successful servitisation [28,47]. Lenka et al. [48] distinguished among intelligence capability (i.e., to sense and capture information), connect capability (i.e., to connect digitalised products through wireless communication networks), and analytic capability (i.e., to benefit from abundant data).

However, as Kohtamäki et al. [24] argued, the role of digital capabilities differs considerably depending on the business model, becoming more relevant in the transition to a service-dominant business. In the first stage ('product provider'), some smart features are merely offered on the basis of remote diagnostics that are required, whereas, in the latter stage (being a 'platform provider'), an operator may monitor, control, optimise, and provide ecosystem-enabling autonomous products (e.g., vehicles).

Considering manufacturing and connecting digital capabilities along with training and software skills, de la Calle et al. [49] examined 2000 Spanish manufacturing companies and found the key role of digital capabilities for Internet-based marketing such that advanced manufacturing technologies did not have a positive and significant impact on servitising except when combined with these connection capabilities.

Parida and Wincent [4] highlighted that the rapid development of digitalisation, circular economy, and servitisation is forcing firms to develop new types of competitive advantages. However, new challenges arise in addition to the aforementioned barrier of capabilities access. With billions of devices already connected to the Internet of things (IOT), new security considerations arise. Security, privacy, and digital ethics become an integral part of the process.

2.3. Supply-Chain Integration and PSI

PSI warrants more networked and matrix-type organisational structures [50]. Thus, the company should increase and reinforce the interaction within its ecosystem, thereby integrating the supply chain.

SCI can be defined as the extent to which a firm's strategy collaborates and manages the intra- and interorganisation processes with its supply chain [51] to achieve effective and efficient flow of products, services, information, money, and decisions seeking maximum value to its customers [52]. Two key aspects emerge from this definition: multidimensionality and its importance as a competitive tool. Studies have classified multidimensionality as internal and external integration [53]. The definition of the integration dimensions is key to determining the scope and limitations of the research study regarding the effect of integration on business outcomes [54]. Thus, this study considers the approach to SCI from two dimensions, internal and external. Furthermore, external dimensions are categorised as customer and supplier integration. Thus, internal and external integration are complementary and exclusive to include and manage the whole supply chain.

Internal integration represents the extent to which a firm's functional departments collaborate and work interactively in a structured manner [55].

External integration can be defined as the degree to which a firm's strategy collaborates with its external partners by building a collaborative, synchronised, and cohesive supply chain [56]. Shah et al. [57] stated that, in pursuing servitisation goals, companies should develop stronger relationships with key supply-chain partners to manage supply- and customer-side uncertainty and complexity. Moreover, the degree of servitisation may be another conditioning element. Spekman et al. [58] argued that the relationships evolve from the negotiation of an open market through cooperation and coordination until collaboration, characterised by SCI, joint planning, and technology and knowledge shared between partners. Following exploratory interviews, Lambert et al. [59] and Whipple and Russell [60] presented two models with small differences and specified in three levels of integration: Type I, the firms recognise each other as partners and share limited operational information; Type II, the firms collaborate in decision making at a tactical/managerial level; Type III, the firms collaborate in process management based on knowledge sharing and joint decision-making.

From the servitised manufacturers' perspective, SCI may be an interesting capability. SCI generates a sense of belonging that favours a climate of trust and commitment [61]. These characteristics allow access to the resources and capabilities of suppliers and customers, as well as exploiting their potential to generate maximum added value to the products or services offered [62]. In the framework of the supply chain, it is recognised that an important part of innovation processes occurs in customer-supplier relationships [5]. This view is also shared by Lambert and Cooper [63], who highlighted that the real source of sustainable competitive advantages is the capacity and ability of supply-chain firms to improve and create value through innovation.

In the traditional product-oriented approach, according to organisational capability theory, integrated capabilities promote a continuous and timely flow, leading to the fulfilment of manufacturing orders [64].

In a service-oriented approach of a manufacturing firm, substantial differences exist between product and services owing to the intangible, heterogeneous, and perishable nature of the service. Thus, it demands additional resources and capabilities [28] which reconfigure all the previous interactions within the supply chain.

From the strategic management perspective, Leuschner et al. [65] referred to SCI as a firm's strategic resource or capability. However, as mentioned earlier, a servitised offering requires a combination of resources and capabilities compared with a product-oriented company. Adams et al. [66] suggested exploring the internal capabilities to better understand the efforts needed by the supply-chain partners.

SCI also plays an important role from the perspective of process efficiency and waste control. Thus, SCI can facilitate the often-complicated process of reverse logistics [67]. Mondragón et al. [68] empirically demonstrated how SCI affects closed-loop supply chains. The scope of SCI should not only be limited to the end of a product's useful life but also cover the product's lifespan. In addition, it should not be restricted to the product alone but should include the waste generated from its operation, which could be relevant to the capital goods sector.

2.4. Sustainability in Digital PSI

Since the 1980s, from the corporate responsibility perspective, the market focus has been on triple bottom line concept in the social, environmental, and economic sphere [69].

As society recognises the need to shift towards more environmentally and socially sustainable way of life, companies have witnessed a radical change in their environment. This is a consequence of stringent regulations and the effects on their own stakeholders and markets, particularly customers. Their customers demand other sustainable responses, requiring innovation in products and services. Accordingly, companies must make strategies to ensure sustainability in all three dimensions, economic, social, and environmental, taking into account that their strategic objectives exert a reciprocal influence [70].

2.4.1. Economic Sustainability

Considering PSI-related economic sustainability, both defensive and offensive perspectives should be considered by companies that offer services to avoid commoditisation of products [71] and to innovate markets and revenue sources, respectively.

However, frequently, the same strategy may be offensive or defensive on the basis of competitors or the circumstances. Distinctive capabilities become a threshold [72], for example, developing a solution such that PSS is considered an innovation until customers demand the same from competitors as a basic requirement. However, firms that do not provide this solution lose out from competition.

Traditionally, services are considered to provide higher profit margins than products [73] as consistent revenue stream [74], while requiring fewer resources [75], and they can be developed on an installed base of products with a long history and expected life cycle [32,76].

The literature focuses on competitive motivations for PSI. Increasing customer expectations in mature markets pushes companies to provide services [26,77]; however, it is interesting in the early stages of the product life cycle, where, for example, pioneers can open a new market by reducing customer risks through providing solutions [11].

In strategic management, economic sustainability is linked to a sustainable competitive advantage [78] acquired through sustainable capabilities [72]. Moreover, because of their intangibility [79] and closer customer-provider relationship, this implies complex links and causal ambiguity, which makes it inimitable.

2.4.2. Environmental Sustainability

PSS have become popular in research on business and sustainability in general and on environmental sustainability in particular. Hallstedt et al. [9] highlighted the role of digital technologies for becoming effective in an innovative circular economic business model based on product servitisation. Furthermore, there are some optimistic expectations about the effect of PSS on the environment. Some researchers have stated that servitisation leads to optimisation in different business areas such as energy consumption [80], thus reducing pollution emission (CO₂, NO_x, SO_x, particulates, etc.) and waste production levels [81], thereby enhancing product lifetime, recycling products, and reusing packaging material [7]. Specifically, result-oriented PSS are considered to boost optimisation as products become investment and cost for manufacturers [8]. There are also interesting opportunities for implementing a circular economic model linked to upgradability as a life-cycle extension strategy, which can be particularly relevant for products that involve significant investment by the customer and whose technology is evolving rapidly [82], such as with some types of capital equipment.

However, Hojnik [83] highlighted the risk of oversimplifying the relationship between servitisation and sustainability. The relationship appears more complex than expected. Furthermore, adopting PSS adoption does not automatically improve the environment, such as the dematerialisation of economy, energy consumption, and waste reduction. Tukker [27] highlighted that PSS is not the remedy for radically improving environmental sustainability. Focusing on waste management, Corvellec and Stal [84] found that the waste effects of PSS do not depend on the orientation on product, use, or result but on how the firm organises residual material flows. Doni et al. [80] did not find an effect of servitisation on firms' environmental policies, whether at the firm level or at the supply-chain management level.

Therefore, there is a need to better understanding the impact of PSS in the environmental domain. Although some researchers (e.g., [27]) analysed the potential of environmental sustainability of various services, empirical research on these relationships has been scarce [85].

2.4.3. Social Sustainability

Consistent with the current trend in sustainability from the triple bottom line perspective, companies should consider expectations beyond their boundaries. The interests and effects of companies' decisions must be considered from a holistic perspective, including external stakeholders, such as customers, suppliers, citizens, and government. Thus, a company undertakes other organisational actions different from those that are merely economic-oriented, such as informing the society, its shareholders, or its employees about its economic, environmental, and social activities [86]. Although several studies on servitisation and sustainability exist, studies on sustainability focused more on the economic and environmental aspects. Given the interdependence between the three aspects that represent sustainability, studies that do not consider all three at the same time will not be clear enough to understand the real effect of the PSS on sustainability [87]. Some authors analysed sustainability from the triple bottom line perspective. Annarelli et al. [88] stated the need for integrating environmental analysis with economic perspective. Hallstedt et al. [9] identified two risks of having a partial analysis of sustainability. In the first case, there is a risk of sub-optimisation if not all dimensions are considered. In the second case, there is the risk of avoiding only punctual and current effects and not the risks that arise from relational effects between dimensions of sustainability.

There is a lack of literature on the social perspective, except for a study on its effect on employment. Moreno et al. [89] argued that, for developing economies, fostering servitisation leads to social impact due to job shifts from manufacturing to service-centred businesses. Although the social dimension is a broader perspective, there are limited studies on this topic.

Social impact can be analysed from internal and external approaches. The internal approach refers to the social impact linked with the company employees. The external approach covers the remaining stakeholders, including customers, suppliers, and society.

The internal approach deals with concepts linked with human resources management. Tseng et al. [90] found out the interest of developing a sustainable PSS for developing employees' participation and self-actualisation. From the internal perspective, it can be considered the offer of specific training programmes for shifting from manufacturing to a servitised business model or the possibility of offering an interesting professional growth.

Regarding the external dimension, in addition to direct employment, there are other externalities that affect the economy and other actors, close or distant, through the company's demand on its suppliers. However, the service effect can generate social value, which facilitates the extension of social effect in contrast to cases where there is a trade-off between profitability and social benefits [91]. Furthermore, through collaboration, product and service innovation drives innovation through open innovation [92].

3. Methodology

This study is based on the work of Yin [93], who defined five research strategies (i.e., experiment, survey, analysis of archives, historical analysis, and case study) and three conditions to select the most appropriate method. These conditions are as follows: (1) the type of research question, (2) the degree of the researcher's control over the actual behavioural events, and (3) whether the analysis involves contemporary or historical events.

This research study was conducted from an exploratory approach to highlight the phenomena of PSI, digitalisation, and sustainability. Although some studies focused on PSI and digitalisation [44,94], few studies have included their effects into sustainability, especially from the triple bottom line approach.

Thus, this study was founded on 'how' and 'why' questions because of the need to understand the real issues and concerns about the impact of digital PSI on sustainability and the role played by SCI. Moreover, we have no control over the events, and the focus of this study was on a contemporary phenomenon in a real-life context. Therefore, according to Yin [93], the case study method is the best approach for this study. It is particularly

interesting where there is no integrated theory and there is a complex interaction of factors [95].

Yin [93] identified two main weaknesses when developing this research method. The first is the lack of rigour when collecting data and interpreting the results and the second is about the difficulty in generalising the findings. These problems affect the internal and external validity of the instrument. Therefore, a systematic case study method was used to address the first issue [96]. Moreover, three senior researchers were involved in collecting, processing, and analysing the data to achieve a high level of reliability. As for the second weakness, the research study was based on a multiple-case study as comparative results can be analysed through ‘within-case’ and ‘cross-case’ analysis [93] and can reduce observer bias. Hillebrand et al. [97] argued that, when a researcher can devise a logical argumentation in support of causal relationships, it is reasonable to conclude that these causal relationships are also valid for structurally similar cases. Thus, the case studies were first independently evaluated and cross-checked to obtain a general consensus [96]. Then, a cross-case analysis enabled an identification of common issues.

In the previous sections, the purpose, the main objectives of the research study, the theoretical models, and a literature review were presented. Thus, there is a holistic understanding of the analysed problem for the definition of the method for data collection.

3.1. Research Framework

With digitalisation proving to be a clear trend affecting PSI and SCI in light of their need for the required transformation, we analysed the impact of digitalisation on sustainability from a holistic perspective, encompassing its environmental, economic, and social aspects (see Table 1).

Table 1. Research framework.

Domain of Analysis	Analysed Dimensions	References
Servitisation taxonomy	Digital services and consultancy Customisation Financial services Logistic services Installation and setup services Management and operation services Maintenance and support services Disposal and conversion services	Mastrogiacomo et al. (2017)
Digitalisation	Efficiency improvement Cost reduction New functionalities New service	Adapted from Cenamor et al. (2017); Kindström and Kowalkowski (2014); Porter and Heppelmann (2014); Coreynen et al. (2016)
Supply-chain integration	Supplier integration Customer integration Internal integration	Adapted from Zhao et al. (2011)
Economical sustainability	Strategy type: Defensive strategy Differentiating Growth and new opportunities Source of economic sustainability Better fulfilment of customer needs Stronger customer relationships Differentiation and lockout competitors Increased revenues Identification of new markets and better response agility Access to service data Reduced customer risk Improved technology Reduced life-cycle costs	Adapted from Neely, 2008; Suarez et al., 2013; Kohtamaäki et al., 2013; Cusumano, 2010; Oliva & Kalenberg, 2003 Adapted from Yang and Evans, 2019

Table 1. Cont.

Domain of Analysis	Analysed Dimensions	References
Environmental sustainability	Resources efficiency Longer product life Increased product usage Reuse and recycling Dematerialisation Liberty for sustainable design	Adapted from Yang and Evans, 2019
Social sustainability	Increased employment Local supplier development Induced demand Health and security Open innovation	Adapted from Yang and Evans (2019); Beuren et al. (2013) and United Nations (Sustainable Development Goals)

We defined the model used in our analysis on the basis of the research question and the literature review. As the main goal of this research was to identify the opportunities for digital services regarding sustainability, we used a service taxonomy to classify the services offered by the companies considered herein. Thus, digitalisation, SCI, and sustainability (economic, environmental, and social) were measured, and the results were organised according to the selected service taxonomy.

3.2. Case Selection

The definition of the unit of analysis and the case selection process are key to the case study method. In this study, the unit of analysis was the company and case selection was based on three criteria: (1) manufacturers firms were selected from the Basque Country; (2) we chose firms that provide a combination of basic and advanced services; (3) it was necessary for the companies to be engaged in the capital goods sector.

The companies were selected from a dataset consisting of 106 Basque manufacturing companies that participated in a PhD research on the role of SCI as a competitive tool [98]. Each company was categorised by its servitisation level, using, in the first case, the SABI database, which contains financial information about Spanish and Portuguese companies, and, in the second case, the services offered through companies' website [99]. To research that aspect, the level of servitisation was established according to the servitisation continuum [14] and the related Baines and Lightfoot [28] servitisation categorisation. A high statistically significant correlation was observed between them (Spearman's rho was equal to 0.834).

The cases were selected from those companies having a third and fourth level of the Baines and Lightfoot [28] servitisation categorisation, which means that intermediate and advanced services are offered. This criterion ensures that, in the finally selected companies, there is coexistence between basic and advanced services. Finally, from all the companies that met these criteria, capital goods manufacturing companies were selected. Other practical issues such as the willingness to participate and accessibility were also considered. Therefore, as the study was a multiple-case research approach, four companies were selected for participating in the study (see Table 2): Companies A, B, C, and D.

Companies A, B, and C are those with more than 250 employees, while company D is an SME. While companies A, B, and C can be considered large companies regionally, they are small compared with global competitors. All four companies are active in the B2B markets, specifically, in the capital goods sector. Only one is also working in the B2C context. Companies A and B are well-established businesses that have existed for more than a century.

Table 2. Characteristics of selected companies.

Companies	Industry (NACE Codes)	Age of the Firm (Years)	Size (Employees)	Operating Markets
Company A	C29—Manufacture of motor vehicles, trailers, and semitrailers	>100	>250	B2B
Company B	C30—Manufacture of other transport equipment	>100	>250	B2B
Company C	C28—Manufacture of machinery and equipment n.e.c.	>40	>250	B2B
Company D	C28—Manufacture of machinery and equipment n.e.c.	>30	<250	B2B and B2C

3.3. Data Collection and Analysis Process

The data-gathering instruments were centred on secondary and primary data (see Table 3). The first step was to collect and review public information about companies, focusing on their service offering and annual reports, such as corporate social responsibility, sustainability, and financial reports. After analysing all available public information, the second step was to define the case study protocol for collecting primary data. Here, data were collected through semi-structured interviews. All the interviewees held senior management positions in their companies and had a global vision, which allowed for in-depth understanding of the topic under study. After explaining the study objective and the required information through emails and preview interviews and conversations, the main interviews of about 2 h duration were conducted. Within a week of the interview, a report on each interview was sent to the respective participants [93]. Once the interviewees reviewed the report, having been given a deadline of 1 week, more video-call interviews were conducted to clarify or to expand on some issues. Thus, we employed a triangulation of active and passive data to verify the accuracy of the information.

Table 3. Information of primary data collection.

Companies	Interviewee	Gender/Years at the Company
Company A	Head of Corporate Human Resources and Corporate Social Responsibility	Male/>10
Company B	Head of Corporate Human Resources and experience in other Managerial positions: Strategic Unit director and Commercial responsible	Male/>20
Company C	CTO—Chief Technology Officer	Male/>25
Company D	R&D Manager	Male/>15

With the primary and secondary information, we developed a ‘within-case’ table to understand each company’s position according to the research study’s focus. This table was compared with that of each company. Subsequently, a cross-case analysis was conducted to identify patterns or differences between the selected companies to understand the opportunities and how the digital PSI affects sustainability.

The collected information was organised in three areas. The first one dealt with the identification of companies’ services according to the Mastrogiacomo et al. [35] service categorisation. Therefore, we asked about the current and forecast incomes, the role of digitalisation in their offering, and the main barriers to offer and bill the services the company identified. The second area concerned the role of SCI in offering the service. Internal, supplier, and customer dimensions were analysed. Lastly, the third area was about sustainability from the triple bottom line approach. Thus, environmental, economic, and social issues were addressed to understand the impact of digital PSI on them.

4. Results: Impact of Digital Services on Sustainability for Manufacturing Companies

4.1. Identification of the Services

PSI manifests in manufacturing companies as different types of services coexist in the same company. Most are product-oriented PSS, although there are also result-oriented and use-oriented PSS [27]. However, some of them involve advanced services, which imply a higher degree of integration internally and in the supply chain [14], while others are basic services [28]. However, services related to the same function, such as maintenance, require different servitisation levels, depending on the level of management and operation and new client needs. Thus, Oliva and Kallenberg ([32], p. 168) considered the relationship with customers and classified services related to maintenance in various categories.

Therefore, according to the taxonomy proposed by Mastrogiacomo et al. [35], we compiled the various services offered by companies under study. However, the first aspect in the first category is as follows: ‘Consultancy services: advice and assistance related to your expertise’, whereas digital services are becoming more important [100]. Therefore, we modified the taxonomy to include and highlight digital services. Thus, the first category ‘Consultancy services’ was transformed into digital services and consultancy. Moreover, we found that none of the companies studied offer ‘Retail sales and distribution services (with an articulated organisation to support customer service)’, which is not surprising because, in all cases, we referred to industrial services, which, in turn, led us to elimination of this category from this study in the B2B context.

Table 4 indicates the relationship between the types of services (adapted from Mastrogiacomo et al. [35]) used with the PSS typology [27] and the level of servitisation, according to Baines and Lightfoot [28], Oliva and Kallenberg [32], and Martinez et al. [14]. This is particularly relevant because capital goods manufacturers have been found to lag behind in their offerings of advanced services compared to other sectors [101].

For a better understanding of the analysis, Table 5 provides the specific content of the various services in the companies considered.

Table 4. Relationship between taxonomies of services.

Services Adapted from [19]	PSS [27]	Servitisation Level [14,28,32]
1. Digital services and consultancy. Advice and assistance related to the firm’s expertise and data	Product-oriented PSS	Advanced/relationship-based
2. Product customisation Customised product design and development services	Product-oriented PSS	Advanced/relationship-based
3. Financial services Long-term credits related to the products, rental contracts, leasing, etc.	Use-oriented PSS	Advanced/relationship-based
4. Logistic services The company provides delivery, transport, and/or storage services for its customer’s products, components, or raw materials	Product-oriented PSS	Basic-intermediate/transaction-based
5. Installation and setup services The company installs and tests its products and trains the personnel in charge of their use.	Product-oriented PSS	Intermediate/transaction-based
6. Management and operation services The customer receives only the benefits of product use without having to execute it	Result-oriented and use-oriented PSS	Advanced/relationship-based
7. Maintenance and support services Not only corrective maintenance and support services during the life cycle of the product, offering spare parts, but also predictive.	Product-oriented PSS	Basic/intermediate (usually)/transaction based/advanced (seldom)/relationship-based
8. Disposal and conversion services Recycling or conversion services usually at the end of the product life cycle.	Product-oriented PSS	Intermediate/transaction-based

Table 5. Services provided by the companies under study.

Services	Company A	Company B	Company C	Company D
1. Digital services and consultancy	Connected products (IOT) and more competitive services for operators and maintainers through data collection, storage, processing, and analysis, such as geolocation, remote human machine interface, remote condition monitoring, condition-based maintenance, energy efficiency (i.e., to reduce energy and fuel costs by calculating the optimum operating patterns and providing the operator with real-time suggestions).	Connected products (IOT) and more competitive services for operators and maintainers through data collection, storage, processing, and analysis, such as diagnostic tool for the different systems working in the product, training for dealers and distributors, fleet manager to optimise the performance and profitability of customers' fleets, ad fuel efficiency and carbon dioxide emissions data directly from the vehicle, to make decisions and optimise resources.	Connected products (IOT) through an on-premise platform and more competitive services for customers and maintainers through collection, storage, processing, and analysis of data. Integral advisory service (compliance with local/global regulatory norms and specifications) and simulation models to demonstrate all key features (mechanical, thermal, electrical, etc.) considering real case scenarios. It leads to a proposal of different alternatives of energy conversion, generation, or consumption. In some cases, global engineering integration of the complete solution (complete project management).	Connected products (IOT) through an on-premise platform and more competitive services for customers and maintainers through collection, storage, processing, and analysis of data. Service of simulation models for comparing the current performance with the potential performance of their products. Integral advisory service (use of building information modelling and virtual reality for visualising the product in the place it will operate in the customer installation).
2. Product customisation	All products are customised. It is not considered a separate service. The weight of the design is crucial in the project (lasts months).	Customised product design and development through the combination and adaptation of modules.	All products are customised as a part of the integral design of the solution. In some sectors, that design can be invoiced separately (small batches). Key parts of the product are modular.	Customised product design and development through the combination and adaptation of modules(they have standard products, generally focused on the end customer, B2C).They have software to select and size the equipment on the basis of the customer's requirements.
3. Financial services	They form part of the capital of the shared company, which may be a financial entity that remains in operation for 30 years. The client receives the service, by kilometres or fixed price: quota.	Service not provided by the firm.	Service not provided by the firm.	Service not provided by the firm.

Table 5. Cont.

Services	Company A	Company B	Company C	Company D
4. Logistic services	Management of the collection and sale of spare parts. Logistics management for materials in the workshop. Delivery planning according to workshop activities. Delivery planning according to workshop activities. Warehouse management. Vendor-managed inventory (VMI) service.	Service not provided by the firm.	Service not provided by the firm.	Service not provided by the firm.
5. Installation and setup services	Complete solutions and integrated or turnkey systems.	Service not provided by the firm.	Complete solutions and integrated or turnkey systems.	They do not install but setup the product.
6. Management and operation services	System operation.	Vehicle operation.	Service not provided by the firm.	System operation (an incipient area, mainly in the hotel sector) and fundamentally through the digital service platform.
7. Maintenance and support services	Preventive and corrective maintenance for their own branded and for other-branded products.	Preventive and corrective maintenance for their branded products. 24 h assistance in more than 1000 official assistance points in the five continents). Digital service platform.	All business units offer both preventive (through advanced digital services and local operators) and corrective maintenance for the products they supply. 24 h assistance and 'on-site' placement (when required) are common in more than 1000 official assistance points on the five continents.	Preventive and corrective maintenance but not 24/7 and for their own branded products. The digital platform is the key to make up, in a way, for not having a 24/7 maintenance service.
8. Disposal and conversion services	Product end-of-life refurbishment and service upgrades.	Refurbishment and modernisation of the product.	Refurbishment and modernisation of the product.	Service not provided by the firm.

4.2. Impact of Digitalisation on Services

Furthermore, digitalisation is transversal to the organisation, and this is reflected in the other services offered and not only through digital services. Therefore, considering previous research to identify the variables, Table 6 shows the effects of digitalisation on various services and helps distinguish whether it has led to improved service efficiency [102], reduction in costs [33], new functionalities [38], or even the appearance of new services [41]. Regarding service efficiency and cost reduction, although cost is part of efficiency, we consider them separately to identify the digital effects on each aspect. Therefore, for the purpose of this research, ‘efficiency’ refers to how well the organisation uses its resources in terms of quality, delivery time, communication workflows, and other benefits such as preventive actions that are valued by the customer, while ‘cost’ refers to the effect of digitalisation specifically in terms of cost reduction. In addition, new functionalities and new service offerings aim to improve the customers’ perceptions, among other factors. In some cases, a higher level of customer participation in a particular service is required.

Table 6. Effect of the digitalisation of the service.

		1. Digital Services and Consultancy	2. Product Customisation	3. Financial Services	4. Logistic Services	5. Installation and Setup Services	6. Management and Operation Services	7. Maintenance and Support Services	8. Disposal and Conversion Services
Company A	EFFIC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	COST	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
	FUNCT	Yes	Yes	No	No	Yes	Yes	Yes	Yes
	NEWS	Yes	Yes	No	No	No	Yes	Yes	Yes
Company B	EFFIC	Yes	Yes	—	—	—	Yes	Yes	Yes
	COST	Yes	Yes	—	—	—	Yes	Yes	Yes
	FUNCT	Yes	Yes	—	—	—	Yes	Yes	Yes
	NEWS	Yes	Yes	—	—	—	Yes	Yes	Yes
Company C	EFFIC	Yes	Yes	—	—	Yes	—	Yes	Yes
	COST	Yes	Yes	—	—	Yes	—	Yes	Yes
	FUNCT	Yes	Yes	—	—	Yes	—	Yes	No
	NEWS	Yes	Yes	—	—	No	—	Yes	Yes
Company D	EFFIC	Yes	Yes	—	—	Yes	Yes	Yes	—
	COST	Yes	Yes	—	—	Yes	Yes	Yes	—
	FUNCT	Yes	Yes	—	—	No	No	No	—
	NEWS	Yes	Yes	—	—	No	No	No	—

Types of effect of digitisation: improves service efficiency (EFFIC), decreases service costs (COST), enables new functionalities (FUNCT), or determines service occurrence (NEWS). — Service not provided by the company.

All companies identified efficiency and cost improvements in all services provided. Financial services (only provided by Company A) were an exception. In reality, the incentive for efficiency and cost improvements is maximised because the supplier is the owner [24,85]. The firm runs the product by adding value of separating use and ownership. Consequently, this study considers that these benefits are not derived from the financial service but exist. Moreover, in most cases, they enable new functionalities and even determine the appearance of the service, except in the case of basic services (logistic services, installation and setup services), particularly company D, which is starting to provide operation services.

Interestingly, some nondigital services were possible because of digitalisation, such as in-product customisation, product operation, maintenance services, or modernisation and life extension.

Company D shows how the digitalisation of the maintenance service could compensate for the unavailability of a 24/7 service. Its digital platform service allows for better management of maintenance work, enabling efficient service. On the same platform, another service allows the customer to obtain a quotation autonomously.

4.3. Role of SCI Dimensions in the Different Services

SCI has a significant impact on PSI; therefore, this study examined the differences in the level of SCI required by various services. In particular, we analysed existing relationships both internally, i.e., within the company, and externally, i.e., with its suppliers

and customers. To determine the level of integration at both the external and internal levels for each type of service, we used the types of relationships proposed by Whipple and Russell [60]. These range from a purely transactional 'Arm's-length' (ARM) relationship, to a project-based collaboration (PB), and to the deepest collaboration in process management (PM).

Table 7 shows that the three dimensions of SCI analysed herein are important in supplying advanced services such as (1) digital service and consultancy, (2) product customisation, and (3) management and operation services. Consistent with previous research [14,28,32], we differentiated between basic and advanced services. It was less significant in the case of basic services, logistic services, installation and setup services, and disposal and conversion services. Thus, for advanced services, a high and balanced SCI was observed in terms of the distinct dimensions singularly, while, for basic services, the level of integration continued to be high but lower than that for advanced services. Moreover, it was inclined towards a greater relationship in the internal dimension and with customers.

Table 7. Effect of the digitalisation of the service.

Service Categorisation	Company	Supp. Int.	Cust. Int.	Int. Int.
1. Digital services and consultancy	Company A	CP	CP	CP
	Company B	PB	PB	PB
	Company C	CP	CP	CP
	Company D	CP	PB	CP
2. Product customisation	Company A	CP	CP	CP
	Company B	CP	CP	CP
	Company C	CP	CP	CP
	Company D	Irrelevant	ARM	CP
3. Financial services	Company A	CP	CP	CP
4. Logistic services	Company A	ARM	ARM	ARM
5. Installation and setup services	Company A	CP	CP	CP
	Company C	PB	CP	CP
	Company D	ARM	ARM	CP
6. Management and operation services	Company A	CP	CP	CP
	Company B	CPM	CP	CP
	Company D	PB	CP	CP
7. Maintenance and support services	Company A	PB	PB	PB
	Company B	ARM	ARM	ARM
	Company C	PB	PB	PB
	Company D	PB	CP	PB
8. Disposal and conversion services	Company A	PB	CP	PB
	Company B	PB	CP	PB
	Company C	CP	PB	CP

ARM: arm's-length relationship; PB: project-based relationship; CP: collaborative process management relationship.

Supplier integration is interesting in terms of both advanced and basic services, as it contradicts the results of some previous studies. Shah et al. [57], for example, identified the supplier relationship as key to the supply of basic services but not advanced services. However, regarding advanced services, the development of digital services and commitment to PSI means that companies are seeking specialised service providers to support them in aspects such as information security and data storage. Company A highlighted its relationship with Amazon Web services. Depending on their needs, they work with Amazon Web services on the sizing and security of information repositories. The relationship can even consider the service provider 'as one with the company itself', as highlighted by Company D. Moreover, in the analysed cases (especially in A, B, and C), the high level of product and service customisation brings great complexity, and technological content motivates greater collaboration with suppliers. However, the need for collaboration decreases to the extent

that customisation is achieved by combining already designed modules (as in Companies B and D).

With regard to customer integration, the need for greater collaboration was confirmed in advanced services [57,103] and in basic services, thereby contradicting the results of earlier studies. In advanced services, all companies concur on highlighting codesign as a keyword and the necessary involvement of the customer in the digitised PSI offer. However, while Companies A, B, and C operate in an increasingly digitised sector, Company D operates in a more traditional sector, unaccustomed to the digitisation of products. Therefore, Company D has more difficulties introducing its services because customers have still not prioritised this level of servitisation in their businesses. This service commercialisation can be achieved using technology with digital tools for analysing the current situation and comparing with the resulting products or tools for simulation and visualisation through virtual reality and using building information modelling (BIM). This implies that, despite being at a disadvantage owing to the current characteristics of their sector, they have a high degree of integration with both clients and suppliers. However, in the case of advanced-customisation product services, they highlight that supplier integration largely depends on the person in the company in charge of the project. Regarding the level of customer integration in core services, the findings do not contradict existing theory [57,103] but rather nuance it. Continuing with the specific case of company D, the core services analysed are of a one-off nature: (4) logistic services, (5) installation and setup services, and (8) disposal and conversion services. Only service maintenance and support services show continuity over time. It is a capital goods sector and a B2B market, which means that products have longer life cycles than consumer goods.

Internally, a high level of integration emerges as a critical element for basic and advanced services. Thus, all four companies emphasise the importance of collaboration between people and departments, highlighting information sharing and formation of multi-disciplinary teams as fundamental aspects. Here, the relationship identified in the literature was confirmed. Internal integration is fundamental to the development of external integration [57,99,104,105]. For internal integration, in some cases (A and B), the growth in the service has led to reorganisation, with the creation of specific units to develop services, thus clarifying the specification of the relationships in the corporation.

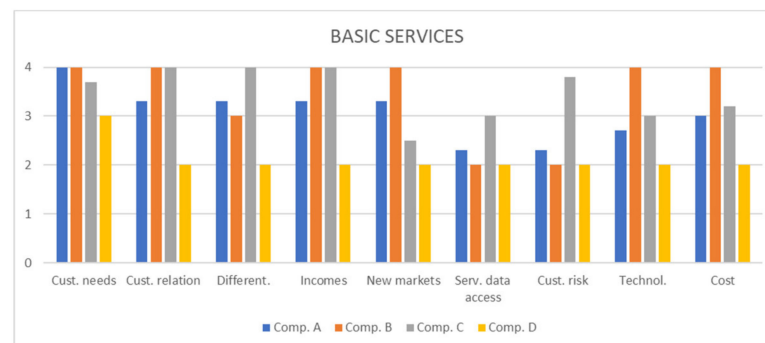
As previously stated in Table 4, given the characteristics of 'Maintenance and support services' and depending on the characteristics and purpose of the service, it could be considered basic/intermediate (usually), transaction-based, advanced (seldom), or relationship-based, ranging from spare parts management to the remote control of the company's products. Here, the level of SCI is lower than that of purely advanced services because, as the interviewees noted, digitalisation is shifting the dyadic supplier–focal company and focal company–customer relationship model towards a more open model, wherein an exchange of data and even an integration of information systems enable certain barriers to be overcome and resolve several problems associated with maintenance management. The possibilities offered by digitalisation in the field of maintenance allow for the remote maintenance supervision of products and development of preventive and predictive plans, among others, by providing operating data in real time. They also changed how companies relate to suppliers and customers by enhancing the relationship with both suppliers and customers.

4.4. Sustainability

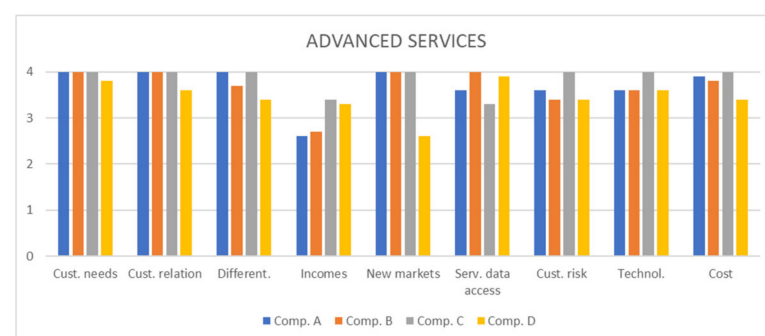
Lastly, this study considers the impact that various services have on the three types of sustainability from the firm perspective. To be sustainable, a firm must be profitable, as well as environmentally and socially responsible. Our analysis was carried out for each service; however, we also measured the effect of classifying the services as either basic or advanced because both types coexist in all the selected companies. Thus, the differences in PSI with respect to sustainability dimensions, per service and per type of service, could be identified.

4.4.1. Economic Sustainability

With regard to economic sustainability, we used different variables considered in the PSI literature, following Yang and Evans [85]: better fulfilment of customer needs, stronger customer relationships, differentiation and lockout competitors, increased revenues, identification of new markets and better responsiveness, access to service data, reduced customer risk, improved technology, and reduced lifecycle costs. Figure 1 shows the higher potential of all economic sustainability variables in advanced services than in basic services. In digital services, the potential is even higher in most variables except in reducing customer risks (specifically associated with result-or use-oriented PSS) and in increasing income. Basic services also positively affect economic sustainability with a greater capacity to increase income but a less potential for differentiation. Basic services serve as a competitive tool for differentiation in the case of Company C because of its business and the context in which it competes. Although it is a large company in regional and national terms, it is small compared with the large global players. Therefore, it uses personalisation, in terms of both product and service, to differentiate its offer. They have the space and resources to train their customers in product maintenance, which is a company strategy, given that having their own maintenance teams would be costly due to the characteristics of their sales, which are atomised and have few units.



(a)



(b)

Figure 1. Impact on economic sustainability: (a) basic services; (b) advanced services.

Although it is interesting to distinguish the way each variable is impacting competitive advantages such as defending the market, as well as differentiating and opening up new business opportunities, the relationships between variables and competitive advantages are not evident. Studies have identified a difficulty of billing for services [106,107], which prevents a clear distinction from the economic effects of these services. The effects are mixed, making it more complex to determine the level that is needed in order to stay in the market; therefore, they become threshold capabilities, or, in contrast, they allow the company to differentiate themselves and drive the market. Such a situation can be observed in the companies in our analysis. Many services are integrated into the product offer, and

the customer requires them, thereby not allowing for any differentiation. In these cases, the strategy is defensive. However, in the development of the strategy, there are opportunities for service differentiation associated with customer interaction [40]. For example, product customisation is essential in Company A's market; the product is designed and developed specifically for the customer. Design and customisation are threshold capabilities in that sense; however, in its implementation, there are opportunities to strengthen ties with the customer, better understand their needs, and potentially introduce product innovations to provide better answers in the market as previous research has emphasized [15]. However, they support economic sustainability. In this sense, we tried to identify the strategy type for each company and service type (see Table 8).

Table 8. Services and strategy type.

Services	Company A	Company B	Company C	Company D
1. Digital services and consultancy	ALL	ALL	ALL	ALL
2. Product customisation	DEFF It is required	DEFF It is not separated invoiced Typically modularity	DEFF It is not separated invoiced Includes both integration and customisation	DEFF It is required
3. Financial services	DEFF DIFFER Facing smallest competitors	Service not provided	Service not provided	DEFF DIFFER Facing smallest competitors
4. Logistic services	ALL	Service not provided	Service not provided	ALL
5. Installation and setup services	DEFF (1)	Service not provided	DEFF It is required	DEFF It is required
6. Management and operation services	ALL	DEFF It is used primarily for product promotion to key customers and product development, for example, public service fleets	DEFF	ALL
7. Maintenance and support services	DEFF	ALL May be necessary for the sale of new products or may serve to win the sale (differentiate), as well as products already owned by the customer and additional services	ALL It is a key aspect that may serve to win the sale (differentiate) or, more frequently, to obtain new sales.	DEFF
8. Disposal and conversion services	NEW_OPP	ALL Sometimes is part of the sales agreement: repurchasing	ALL Compulsory in some sectors, but can be an opportunity to renew products during lifecycle time for more recent technological ones	NEW_OPP

Strategy type: defensive (DEFF), differentiate (DIFFER), new business opportunities (NEW_OPP), or all strategies suit this category (ALL).

The weight of service sales in turnover is low, i.e., less than 1% in Companies A and B and higher but less than 10% in Companies C and D. However, in addition to the difficulty of separate invoicing, the enormous investment that capital goods represent for clients should be considered, which means the relative importance of services sales

figures cannot be as high as in other sectors. However, they are incorporated into the set of products/services delivered as part of the sale. In addition, the two companies with a lower relative weight of services sales are precisely those with separate service business units. In some cases, the companies found it difficult to obtain the data. One company confessed the following: ‘Even internally, we do not know the breakdown of service sales by strategic unit or division’. However, growth expectations are especially clear in the case of digital business. In other cases, growth expectations are linked to the experience acquired in previous firm movements, such as in the case of one company who is now investing in developing services infrastructures in more geographic locations, after some time delivering the services mainly leveraging on the existing capabilities.

4.4.2. Environmental Sustainability

The impact of digital PSI on environmental sustainability was analysed from aspects related to the effect on longer product life, increased energy efficiency, resource use and carbon reduction, increased recycling and reuse, increased product use, dematerialisation, and the freedom to design for sustainability [85]. An analysis based on companies’ self-assessment, especially through interviews, led us to determine the positive impact of digitalisation of PSI on three indicators: longer product life, increased energy efficiency, and increased product use. These aspects concern the physical good being sold and its energy consumption. These features are the selling points of digital services. All companies analysed, for example, have simulation tools allowing them to compare the equipment currently used by the customer with the products they market. The criteria for comparison include questions on energy consumption, performance, and flexibility of operation. However, we found, as previous studies have also highlighted, that the issue of equipment replacement creates a substantial barrier in capital equipment purchase decisions [82]. The considerable investment required eclipses other factors in the decision; thus, all indicators are frequently translated into the economic aspect and then into the payback time of the investment by the customer. According to Khan et al. [39], a midlife upgrade strategy appears to be a promising method to postpone replacement and incorporate new technologies, opening new service opportunities for manufacturing companies while enhancing the value delivered to customers (primarily related to economic sustainability). Some of the companies herein highlighted the relevance assigned by the clients to customer experience in transport, which was usually heavily conditioned by rapid technological development.

Company A highlights in its R&D&I efforts the use of data capture and transmission tools, including sensorisation and IOT, as well as big data, in addition to energy consumption in other areas of special relevance such as diagnosis, maintenance, and operation. Thus, energy sustainability in the manufacturing activity, including the product and its manufacture, is reinforced.

Energy efficiency is considered key in all four companies. In all cases, it is a prioritised sustainable development goal (SDG) in their sustainability strategies because of its capacity to influence through their activity.

However, the impact on dematerialisation and the freedom to design for sustainability have the least effect on the development of digital PSI. Significant differences are also identified when comparing the larger companies (A, B, and C) with the SME (Company D), which, despite maintaining the same pattern with a greater impact in terms of improved energy efficiency, longer life, and greater use of the product, considers a lower impact. In this respect, Company D stressed how the product–service offer does not lead the customer beyond getting the most out of the product by considering the redesign of the product according to sustainability criteria. The four companies did coincide in speaking of certain dematerialisation thanks to digital PSI due to a reduction in the number of visits to the customer through remote maintenance, where the trip is not required, or by being able to know the characteristics of the error in advance, where spare parts can be carried out in the first service assistance and the natural dematerialisation due to the digitalisation of maintenance manuals.

The analysis of basic and advanced services shows that basic services have a greater positive impact on environmental sustainability. Here, larger companies (Companies A, B, and C) have a higher impact on all environmental aspects in relation to basic services and in advanced services compared with the SME (Company D) (see Figure 2). Company D indicates, sharing the assessment of other companies, that digital PSI allows it to extend product life and reduce environmental impact, thanks to the improved efficiency in energy use.

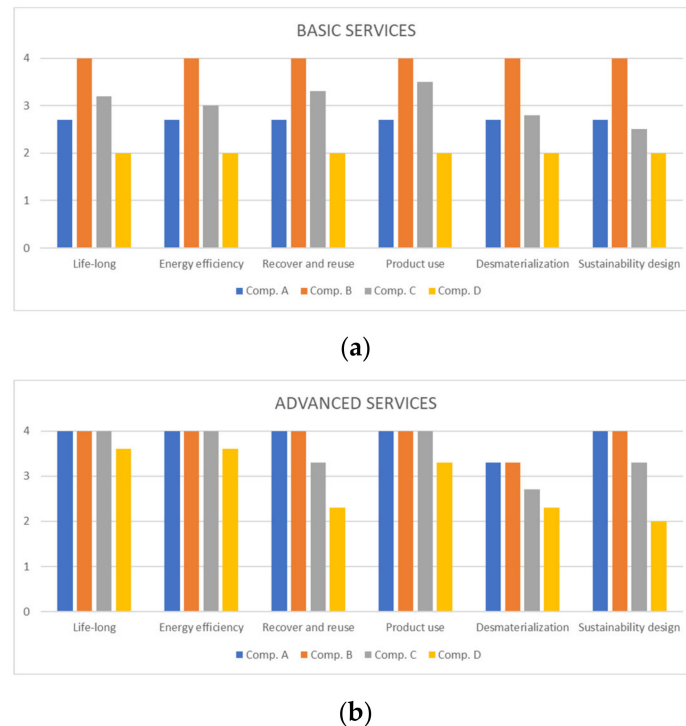


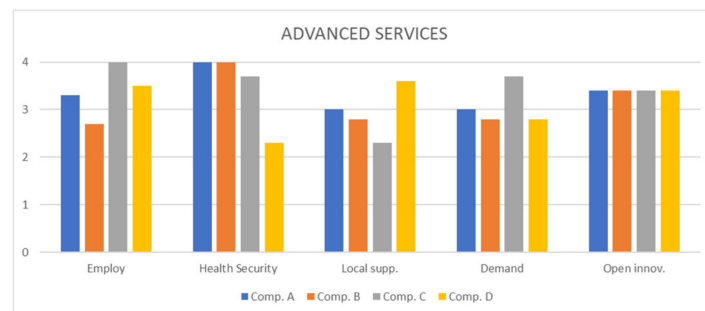
Figure 2. Impact on environmental sustainability: (a) basic services; (b) advanced services.

4.4.3. Social Sustainability

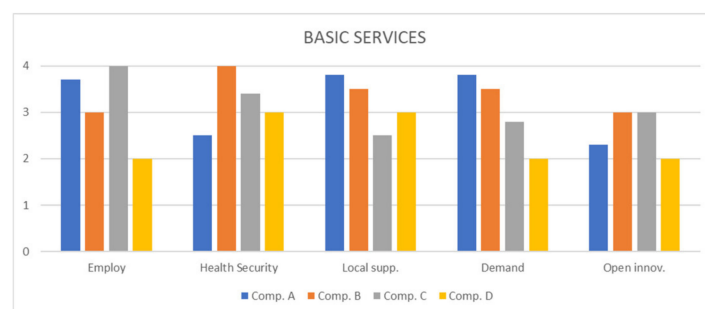
The impact of digital PSI on social sustainability was measured on five aspects according to the literature review [31,88] and the United Nations' Sustainable Development Goals. These aspects are as follows: job creation, customer health and safety, empowerment of local suppliers, induced demand, and open innovation. In Yang and Evans's [85] approach to considering the social sustainability potential of PSS, only the first variable, job creation based on Beuren et al. [108], is considered. According to the aspects that the companies themselves prioritised in the United Nations SDGs, we added the remaining variables indicated.

Overall, this social approach is the least explored dimension in the servitisation literature. The analysis of the companies' evaluations of their opinion on how digital PSI impacts the social dimension of sustainability shows that the impact on each of the aspects measured is more balanced than in the case of environmental sustainability. However, there is no agreement among the companies surveyed that any of the social sustainability indicators used have a lower impact (see Figure 3). For example, Company A indicates that open innovation is the aspect on which the digitalisation of its product–service offering has the least impact. For Company B, it is employment, and, for Company C, it is the strengthening of local suppliers. Company D reports a low impact on two aspects, customer health and safety and induced demand. The consideration of the impact on social sustainability on the digitalisation of the product–service offer is, on average, low and, therefore, lower than the impact that the companies consider having on both economic and environmental aspects. Social dimension objectives seem to be a consequence of pursuing economic and

environmental objectives. These results accord with those of Vifell and Soneryd [109], who stated that the social dimension is often the vaguest in terms of practical attempts towards achieving sustainability.



(a)



(b)

Figure 3. Impact on social sustainability: (a) basic services; (b) advanced services.

Customer health and safety and job creation are the aspects that are highlighted as the main success of digital PSI. Indeed, this observation would apply to both basic and advanced services. Concerning customer health and safety, the assessment of Companies A, B, and C is that it has a high impact, and this is explained by the fact that the sector in which their products are used is mainly transport. The capacity to improve both the product and the product support service or to achieve higher added value would have a direct impact on the perception of quality by end customers and, by extension, on their industrial customers. On the contrary, Company D presents a low impact of digital PSI on customer health and safety and job creation. However, they pointed out that this may change in the future as they are currently working to ensure that their products, related to water and air treatment, help in the prevention of COVID-19, improving the perception of users and, therefore, of those who own their products. As mentioned earlier, a midlife upgrade may prove to be a highly effective strategy in the fields of health and security or customer experience [39].

Regarding the second issue, namely, job creation, all companies point to the positive impact of creating specific positions for managing and exploiting large volume of data. Lafuente et al. [110] demonstrated how knowledge-intensive business services positively impact employment in the manufacturing sector, particularly with respect to start-ups. Although, in absolute terms, hiring new staff is not highly relevant for Companies A, B and C, there is growth due to the creation of new departments or the expansion of existing ones or even the creation of new companies (spin-offs), whose business model is based on the provision of services through the management of the teams' data. Here, it is also interesting to differentiate the responses according to basic and advanced services. Companies A and B have a greater impact on job creation from basic services than from advanced services. The fact that they have a large installed base and require a large workforce due to the type

of product they manufacture can explain this response. Company C, on the other hand, shows a high impact on job creation, from both basic and advanced services.

The impact of digital PSI on the empowerment of local suppliers, on induced demand, and on open innovation is, according to the group of companies, low. The empowerment of local suppliers is perhaps due to the effect of a higher sales volume, thanks to the offer of services, as well as due to the search for expertise and knowledge in an unknown area for the company, especially when talking about issues related to the storage and security of information, processing of large volumes of data, etc. However, as servitisation increases firms' dependency, it is conditioned by other factors such as trust and commitment [111]. In some cases, companies are more exposed to unethical supplier practices [112].

Concerning induced demand, it can be observed that digitised supply can lead to the provision of other services. This question depends on the level of immersion of the sector in digitalisation. Thus, Companies A, B, and C do claim to see some impact, while Company D indicates that the impact is negligible, especially looking at the impact from basic services. Company D operates in a sector where there is not yet a widespread digital culture, which makes offering advanced services a challenge.

The impact on open innovation also depends on the type of service from which it is analysed. Thus, all companies agree that advanced services have a low to medium impact on open innovation, while only Companies B and C take this view when referring to basic services. Companies A and D, especially the latter, report that the impact is negligible. Nevertheless, these findings, together with the high level of SCI in the advanced services of the companies analysed herein, align with Chesbrough [92] in that collaboration is the key ingredient for generating product and service innovation through open innovation. This SCI is also important because of its positive impact on product innovation capabilities [99].

5. Conclusions

Although the literature has shown interest in the possibilities opened up by PSI to drive business sustainability [24,31], there is a lack of empirical research [85]. Furthermore, the results and approach are partial, and an effort is needed to better understand this phenomenon from a broader perspective. Moreover, by delving into specific cases, we provide the reasons and nuances of several elements generically studied in the literature on quantitative research.

In this work, an in-depth analysis of the services offered by the four previously selected manufacturing companies was conducted. The main objective was to find how digital services can affect the sustainability of a company in its different aspects, economic, social, and environmental, compared with the other services. Furthermore, the role of SCI was considered. Consequently, a series of conclusions contribute to the knowledge of this field.

5.1. Theoretical Implications

PSI is considered in the literature as a continuum [11]. Frequently, scholars see PSI or servitisation as a transition from pure products to services (even pure services) that manufacturers must make. However, most companies have experienced that various services coexist with products. In addition, basic services are provided simultaneously with advanced services playing a complementary role. In our analysis, like other scholars [33,34], instead of studying services separately, we considered various services within the same company.

Among those, digital services are critical for manufacturing companies, and they were the focus of our study to compare them with the rest of the services [24]. Therefore, we modified the previous taxonomy [35] to include and highlight them. This approach is novel in the literature.

Confirming the expectations of development opportunities based on digitisation in the literature [4], the analysed companies were consistent with the expected future high growth in digital services. Moreover, digitalisation affects other services, not only digital services. In this study, digital technologies impacted product customisation, logistic

services, management and operation services, maintenance and support services, and even conversion services, leading to an improvement in service efficiency, decrease in costs, new functionalities, or even a determination of service occurrence. Furthermore, digital services allow basic services such as maintenance to become advanced services, and advanced services benefit from digital services [32].

Unsurprisingly, a higher potential of all economic sustainability variables was found in advanced services than in basic services. Among these, digital services were significant. However, basic services are also seen as positively affecting economic sustainability, with greater capacity to increase income but less potential for differentiation.

Nevertheless, some of the most evolved forms of services such as operating systems [24] were found to be, in fact, mere instrumental and defensive strategies. Clients try avoiding risk by passing it on to the supplier, who must accept it to acquire the market but does not see it as a transformational opportunity. In such cases, companies do not consider those services as real opportunities but as tolls to be paid to continue in the market.

Although the literature considers that result-oriented PSS are in the interest of both client and provider [71], at least for the study companies, it is seen as a requirement mainly for the client's benefit. The risk and effort are considered too high. Perhaps, it can be a consequence of the critical mass access to profit on this effort [11,15]. Moreover, as discussed in the literature, new and distant capabilities and investments are required [32]. Despite the difficulties in leveraging significant new sources of revenue and performance, there is a need for manufacturing companies to advance services as a basic tool for economic sustainability.

The impact on social sustainability is more limited than that on the other areas, partly due to its instrumental nature, which limits the effects on employment and generation of economic activity; this occurs if the strategy is defensive or instrumental. The greatest potential in the area of customer health and safety is related to the type of activity conducted by the companies studied, mainly related to transport. In other areas of social sustainability, companies understand sustainability in terms of compliance rather than their ability to be active agents of this transformation. The literature on sustainability has discussed the incoherence between corporate rhetoric and actions [113].

5.2. Managerial and Policy Implications

This study provides useful insights for managers and policymakers as it reveals that digitalisation leverages both basic and advanced services in terms of their impact on economic and environmental sustainability and, albeit to a more limited degree, on social sustainability. In addition, SCI was found to be relevant for digital PSI.

Services have become an indispensable component of manufacturing companies' offerings, making the development of such services necessary as a defensive strategy. It also creates opportunities to generate growth and new business. In this context, ICTs are presented as multi-purpose tools that not only generate new services but also affect other services in the company that typically coexist with each other. Thus, servitisation becomes an interesting method of innovation to improve performance, including in sustainability-related dimensions.

Therefore, companies should be aware of the need to acquire digital technology and the necessary capabilities, including the capability to capture information and the capability to perform analytics [42]. Specifically, with respect to small businesses, given their general lack of resources and capabilities, our findings show the relevance of making an effort to accelerate the digital transformation of such companies. This is in addition to the difficulties that traditionally product-centric companies encounter in shifting towards services.

The results also highlight the key role of SCI in PSI, focusing particularly on the deployment of advanced services. In this sense, it is important for companies to reinforce their interactions with the rest of the value chain, building long-term relationships based on trust and commitment.

For policymakers, helping manufacturing businesses in making this transition, especially SMEs, which form the backbone of enterprise in Europe, should be a political priority. Moreover, given that advanced services have a greater potential to affect sustainability for companies in all respects, a decisive commitment to make progress in this area is necessary. However, optimising equipment and operations can occasionally have undesirable effects in social and/or environmental dimensions. Thus, policymakers should attempt to prevent such outcomes through policies and laws.

5.3. Limitations and Future Research

This study presented some limitations. First, the study was limited to four companies that operate in a B2B environment and in the capital goods industry. Although the case selection process was defined, the selected companies are not necessarily of the same manufacturer pattern. Thus, in spite of their similarities, our findings may be limited in their generalisation. This limitation is inherent to the development of a case study as the research strategy. Second, the companies' headquarters are all located in the same region. Therefore, the effect of regional culture on business management was not considered.

Although we incorporated more variables than previous studies in our analysis of sustainability, not all the possible variables were included; the incorporated variables were treated with a limited degree of scrutiny. For researchers with specific interests in this field, numerous possibilities exist for further development.

Further research is needed to overcome these pitfalls by working on new case studies in the same industry and the same region to identify differences in company behaviour due to the location. Moreover, more evidence is needed on how the digital PSI benefits from the impact of advanced services in the sustainability performance more than the basic services. These differences can be further analysed, considering the effect of size, because, in the study, we identified how the SME (Company D) showed a worse impact on sustainability regarding the basic services than the large companies (Companies A, B, and C), while, in the advanced services, the difference was much lower. New variables and approaches, as well as a more extensive treatment regarding the field of sustainability, would prove considerably fruitful, particularly in relation to social sustainability, which is a less developed topic in the literature. For instance, an in-depth analysis of the links among the various dimensions of sustainability would be interesting.

Author Contributions: All the authors equally contributed in terms of conceptualising, planning and executing this research work, writing original draft and subsequent reviews. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available within the article. It was compiled from notes that the authors took during the interviews carried out and are compiled in the article itself.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Goedkoop, M.J.; Van Halen, C.J.; Te Riele, H.R.; Rommens, P.J. Product service systems, ecological and economic basics. *Rep. Dutch Minist. Environ. (VROM) Econ. Aff. (EZ)* **1999**, *36*, 1–122.
- Porter, M.E.; Heppelmann, J.E. How smart, connected products are transforming competition. *Harv. Bus. Rev.* **2014**, *92*, 64–88.
- Parida, V.; Sjödin, D.R.; Lenka, S.; Wincent, J. Developing Global Service Innovation Capabilities: How Global Manufacturers Address the Challenges of Market Heterogeneity. *Res. Technol. Manag.* **2015**, *58*, 35–44. [[CrossRef](#)]
- Parida, V.; Wincent, J. Why and how to compete through sustainability: A review and outline of trends influencing firm and network-level transformation. *Int. Entrep. Manag. J.* **2019**, *15*, 1–19. [[CrossRef](#)]
- Lundvall, B.-A. Innovation as an interactive process: From user-producer interaction to the national system of innovation. In *Technical Change and Economic Theory*; Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L., Eds.; Pinter Publishers: London, UK, 1988; pp. 349–369.
- Matthyssens, P.; Vandenbempt, K. Moving from basic offerings to value-added solutions: Strategies, barriers and alignment. *Ind. Mark. Manag.* **2008**, *37*, 316–328. [[CrossRef](#)]
- Manzini, E.; Vezzoli, C. A strategic design approach to develop sustainable product service systems: Examples taken from the ‘environmentally friendly innovation’ Italian prize. *J. Clean. Prod.* **2003**, *11*, 851–857. [[CrossRef](#)]
- Tukker, A. Product services for a resource-efficient and circular economy—A review. *J. Clean. Prod.* **2015**, *97*, 76–91. [[CrossRef](#)]
- Hallstedt, S.I.; Isaksson, O.; Öhrwall Rönnbäck, A. The Need for New Product Development Capabilities from Digitalization, Sustainability, and Servitization Trends. *Sustainability* **2020**, *12*, 10222. [[CrossRef](#)]
- Vandermerwe, S.; Rada, J. Servitization of business: Adding value by adding services. *Eur. Manag. J.* **1988**, *6*, 314–324. [[CrossRef](#)]
- Suarez, F.F.; Cusumano, M.A.; Kahl, S. Services and the business models of product firms: An empirical analysis of the software industry. *Manag. Sci.* **2013**, *59*, 420–435. [[CrossRef](#)]
- Bustinza, O.F.; Gomes, E.; Vendrell-Herrero, F.; Baines, T. Product–service innovation and performance: The role of collaborative partnerships and R&D intensity. *R&D Manag.* **2019**, *49*, 33–45. [[CrossRef](#)]
- Carlborg, P.; Kindström, D.; Kowalkowski, C. The evolution of service innovation research: A critical review and synthesis. *Serv. Ind. J.* **2014**, *34*, 373–398. [[CrossRef](#)]
- Martinez, V.; Bastl, M.; Kingston, J.; Evans, S. Challenges in transforming manufacturing organisations into product-service providers. *J. Manuf. Technol. Manag.* **2010**, *21*, 449–469. [[CrossRef](#)]
- Visnjic, I.K.; van Looy, B. Servitization: Disentangling the impact of service business model innovation on manufacturing firm performance. *J. Oper. Manag.* **2013**, *31*, 169–180. [[CrossRef](#)]
- Golara, S. Product-Service Bundling in Manufacturing Firms. Ph.D. Thesis, Arizona State University, Tempe, AZ, USA, 2018.
- Dachs, B.; Biege, S.; Borowiecki, M.; Lay, G.; Jäger, A.; Schartinger, D. Servitisation of European manufacturing: Evidence from a large scale database. *Serv. Ind. J.* **2014**, *34*, 5–23. [[CrossRef](#)]
- Cusumano, M.A. *Staying Power*; Oxford University Press: Oxford, UK, 2010.
- Cusumano, M.A.; Kahl, S.J.; Suarez, F.F. Services, industry evolution, and the competitive strategies of product firms. *Strateg. Manag. J.* **2015**, *36*, 559–575. [[CrossRef](#)]
- Gebauer, H.; Haldimann, M.; Saul, C.J. Competing in business-to-business sectors through pay-per-use services. *J. Serv. Manag.* **2017**, *28*, 914–935. [[CrossRef](#)]
- Mont, O.K. Clarifying the concept of product–service system. *J. Clean. Prod.* **2002**, *10*, 237–245. [[CrossRef](#)]
- Baines, T.S.; Lightfoot, H.W.; Evans, S.; Neely, A.; Greenough, R.; Peppard, J.; Roy, R.; Shehab, E.; Braganza, A.; Tiwari, A.; et al. State-of-the-art in product-service systems. *Proc. Inst. Mech. Eng. J. Eng. Manuf.* **2007**, *221*, 1543–1552. [[CrossRef](#)]
- Tukker, A.; Tischner, U. Product-services as a research field: Past, present and future. Reflections from a decade of research. *J. Clean. Prod.* **2006**, *14*, 1552–1556. [[CrossRef](#)]
- Kohtamäki, M.; Parida, V.; Oghazi, P.; Gebauer, H.; Baines, T. Digital servitization business models in ecosystems: A theory of the firm. *J. Bus. Res.* **2019**, *104*, 380–392. [[CrossRef](#)]
- Mastrogiacomo, L.; Barravecchia, F.; Franceschini, F. Definition of a conceptual scale of servitization: Proposal and preliminary results. *CIRP J. Manuf. Sci. Technol.* **2018**, *29*, 141–156. [[CrossRef](#)]
- Mathieu, V. Product Services: From a Service Supporting the Product to a Service Supporting the Client. *J. Bus. Ind. Mark.* **2001**, *16*, 39–61. [[CrossRef](#)]
- Tukker, A. Eight Types of Product-service System: Eight Ways to Sustainability? Experiences from Suspronet. *Bus. Strategy Environ.* **2004**, *13*, 246–260. [[CrossRef](#)]
- Baines, T.; Lightfoot, H. *Made to Serve: How Manufacturers Can Compete through Servitization and Product Service Systems*; John Wiley and Sons: Chichester, UK, 2013; pp. 1–270.
- Brax, S.A.; Visintin, F. Value Constellations in Servitization. In *Practices and Tools for Servitization*; Kohtamäki, M., Baines, T., Rabetino, R., Bigdeli, A., Eds.; Palgrave Macmillan: Cham, Switzerland, 2018. [[CrossRef](#)]
- Brax, S.A.; Visintin, F. Meta-model of servitization: The integrative profiling approach. *Ind. Mark. Manag.* **2017**, *60*, 17–32. [[CrossRef](#)]
- Bustinza, O.F.; Vendrell-Herrero, F.; Sánchez-Montesinos, F.J.; Campos-Granados, J.A. Should Manufacturers Support the Entire Product Lifecycle with Services? *Sustainability* **2021**, *13*, 2493. [[CrossRef](#)]
- Oliva, R.; Kallenberg, R. Managing the transition from products to services. *Int. J. Serv. Ind. Manag.* **2003**, *14*, 160–172. [[CrossRef](#)]

33. Kindström, D.; Kowalkowski, C. Service innovation in product-centric firms: A multidimensional business model perspective. *J. Bus. Ind. Mark.* **2014**, *29*, 96–111. [[CrossRef](#)]
34. Martinez, V.; Neely, A.; Velu, C.; Leinster-Evans, S.; Bisessar, D. Exploring the journey to services. *Int. J. Prod. Econ.* **2017**, *192*, 66–80. [[CrossRef](#)]
35. Mastrogiacomo, L.; Barravecchia, F.; Franceschini, F. A General Overview of Manufacturing Servitization in Italy. *Procedia CIRP* **2017**, *64*, 121–126. [[CrossRef](#)]
36. Paschou, T.; Adrodegari, F.; Perona, M.; Sacceni, N. The digital servitization of manufacturing: Literature review and research agenda. In Proceedings of the 27th RESER Conference Bilbao, Bilbao, Spain, 7–9 September 2017; Available online: https://www.researchgate.net/publication/319628925_The_digital_servitization_of_manufacturing_a_literature_review_and_research_agenda (accessed on 5 March 2021).
37. Kowalkowski, C.; Gebauer, H.; Oliva, R. Service growth in product firms: Past, present and future. *Ind. Mark. Manag.* **2017**, *60*, 82–88. [[CrossRef](#)]
38. Porter, M.E.; Heppelmann, J.E. How smart, connected products are transforming companies. *Harv. Bus. Rev.* **2015**, *93*, 96–114.
39. Khan, M.A.; West, S.; Wuest, T. Midlife upgrade of capital equipment: A servitization-enabled, value-adding alternative to traditional equipment replacement strategies. *CIRP J. Manuf. Sci. Technol.* **2020**, *29*, 232–244. [[CrossRef](#)]
40. Opazo, M.; Vendrell-Herrero, F.; Bustinza, O.F. Uncovering productivity gains of digital and green servitization: Implications from the automotive industry. *Sustainability* **2018**, *10*, 1524. [[CrossRef](#)]
41. Schroeder, A.; Kotlarsky, J. Digital resources and their role in advanced service provision: A VRIN analysis'. In Proceedings of the Spring Servitization Conference, SSC2015, Birmingham, UK, 18–19 May 2015; Available online: https://research.aston.ac.uk/portal/files/17919118/Proceedings_of_the_Spring_Servitization_Conference_SSC2015.pdf (accessed on 5 March 2021).
42. Reim, W.; Parida, V.; Örtqvist, D. Product Service Systems (PSS) business models and tactics—a systematic literature review. *J. Clean. Prod.* **2015**, *97*, 61–75. [[CrossRef](#)]
43. Grubic, T. Servitization and remote monitoring technology: A literature review and research agenda. *J. Manuf. Technol. Manag.* **2014**, *25*, 100–124. [[CrossRef](#)]
44. Lerch, C.; Gotsch, M. Digitalized Product-Service Systems in Manufacturing Firms: A Case Study Analysis. *Res. Technol. Manag.* **2015**, *58*, 45–52. [[CrossRef](#)]
45. Benedettini, O.; Davies, J.; Neely, A. *A Capability-Based View of Service Transitions*; Working paper; University of Cambridge: Cambridge, UK, 2015; Available online: http://cambridgeservicealliance.eng.cam.ac.uk/Resources/Downloads/Monthly%20Papers/2015April_Capabilitybasedviewofservicetransition.pdf (accessed on 8 March 2021).
46. Kowalkowski, C.; Witell, L.; Gustafsson, A. Any way goes: Identifying value constellations for service infusion in SMEs. *Ind. Mark. Manag.* **2013**, *42*, 18–30. [[CrossRef](#)]
47. Coreynen, W.; Matthyssens, P.; Van Bockhaven, W. Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Ind. Mark. Manag.* **2016**, *60*, 42–53. [[CrossRef](#)]
48. Lenka, S.; Parida, V.; Wincent, J. Digitalization capabilities as enablers of value co-creation in servitizing firms. *Psychol. Mark.* **2017**, *34*, 92–100. [[CrossRef](#)]
49. De la Calle, A.; Freije, I.; Ugarte, J.V.; Larrinaga, M.Á. Measuring the impact of digital capabilities on product-service innovation in Spanish industries. *Int. J. Bus. Environ.* **2020**, *11*, 254–274. [[CrossRef](#)]
50. Nuutinen, M.; Lappalainen, I. Towards service-oriented organisational culture in manufacturing companies. *Int. J. Qual. Serv. Sci.* **2012**, *4*, 137–155. [[CrossRef](#)]
51. Flynn, B.; Huo, B.; Zhao, X. The impact of supply chain integration on performance: A contingency and configuration approach. *J. Oper. Manag.* **2010**, *28*, 58–71. [[CrossRef](#)]
52. Zhao, X.; Huo, B.; Flynn, B.B.; Yeung, J.H.Y. The impact of power and relationship commitment on the integration between manufacturers and customers in a supply chain. *J. Oper. Manag.* **2008**, *26*, 368–388. [[CrossRef](#)]
53. Tarifa-Fernandez, J.; De Burgos-Jiménez, J. Supply chain integration and performance relationship: A moderating effects review. *Int. J. Logist. Manag.* **2017**, *28*, 1243–1271. [[CrossRef](#)]
54. Huo, B. The impact of supply chain integration on company performance: An organizational capability perspective. *Supply Chain Manag. Int. J.* **2012**, *17*, 596–610. [[CrossRef](#)]
55. Chen, I.J.; Paulraj, A. Towards a theory of supply chain management: The constructs and measurements. *J. Oper. Manag.* **2004**, *22*, 119–150. [[CrossRef](#)]
56. Zhao, X.; Huo, B.; Selen, W.; Yeung, J.H.Y. The impact of internal integration and relationship commitment on external integration. *J. Oper. Manag.* **2011**, *29*, 17–32. [[CrossRef](#)]
57. Shah, S.A.A.; Jajja, M.S.S.; Chatha, K.A.; Farooq, S. Servitization and supply chain integration: An empirical analysis. *Int. J. Prod. Econ.* **2020**, *229*, 107765. [[CrossRef](#)]
58. Spekman, R.E.; Kamauff, J.W., Jr.; Myhr, N. An empirical investigation into supply chain management: A perspective on partnerships. *Supply Chain Manag. Int. J.* **1998**, *3*, 53–67. [[CrossRef](#)]
59. Lambert, D.M.; Emmelhainz, M.A.; Gardner, J.T. Developing and implementing supply chain partnerships. *Int. J. Logist. Manag.* **1996**, *7*, 1–18. [[CrossRef](#)]
60. Whipple, J.M.; Russell, D. Building supply chain collaboration: A typology of collaborative approaches. *Int. J. Logist. Manag.* **2007**, *18*, 174–196. [[CrossRef](#)]

61. Bagchi, P.K.; Ha, B.C.; Skjoett-Larsen, T.; Soerensen, L.B. Supply chain integration: A European survey. *Int. J. Logist. Manag.* **2005**, *16*, 275–294. [\[CrossRef\]](#)
62. Soosay, C.A.; Hyland, P.W.; Ferrer, M. Supply chain collaboration: Capabilities for continuous innovation. *Supply Chain Manag. Int. J.* **2008**, *13*, 160–169. [\[CrossRef\]](#)
63. Lambert, D.M.; Cooper, M.C. Issues in supply chain management. *Ind. Mark. Manag.* **2000**, *29*, 65–83. [\[CrossRef\]](#)
64. Huo, B.; Qi, Y.; Wang, Z.; Zhao, X. The impact of supply chain integration on firm performance. *Supply Chain Manag. Int. J.* **2014**. [\[CrossRef\]](#)
65. Leuschner, R.; Rogers, D.S.; Charvet, F.F. A meta-analysis of supply chain integration and firm performance. *J. Supply Chain Manag.* **2013**, *49*, 34–57. [\[CrossRef\]](#)
66. Adams, R.; Jeanrenaud, S.; Bessant, J.; Denyer, D.; Overy, P. Sustainability-oriented innovation: A systematic review. *Int. J. Manag. Rev.* **2016**, *18*, 180–205. [\[CrossRef\]](#)
67. Zailani, S.; Iranmanesh, M.; Foroughi, B.; Kim, K.; Hyun, S.S. Effects of supply chain practices, integration and closed-loop supply chain activities on cost-containment of biodiesel. *Rev. Manag. Sci.* **2019**, 1–21. [\[CrossRef\]](#)
68. Mondragon, A.E.C.; Lalwani, C.; Mondragon, C.E.C. Measures for auditing performance and integration in closed-loop supply chains. *Supply Chain Manag. Int. J.* **2011**, 43–56. [\[CrossRef\]](#)
69. Elkington, J. *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*, 1st ed.; Capstone Publishing: Oxford, UK, 1997.
70. Hristov, I.; Chirico, A. The role of sustainability key performance indicators (KPIs) in implementing sustainable strategies. *Sustainability* **2019**, *11*, 5742. [\[CrossRef\]](#)
71. Neely, A.D. Exploring the financial consequences of the servitization of manufacturing. *Oper. Manag. Res.* **2008**, *2*, 103–118. [\[CrossRef\]](#)
72. Barney, J.B.; Arikan, A.M. The resource-based view: Origins and implications. *Blackwell Handb. Strateg. Manag.* **2001**, *5*, 124–188. [\[CrossRef\]](#)
73. Anderson, E.W.; Fornell, C.; Rust, R.T. Customer satisfaction, productivity, and profitability: Differences between goods and services. *Mark. Sci.* **1997**, *16*, 129–145. [\[CrossRef\]](#)
74. Quinn, J.B.; Doorley, T.L.; Paquette, P.C. Beyond products: Services-based strategy. *Harv. Bus. Rev.* **1990**, *68*, 58–67.
75. Wise, R.; Baumgartner, P. Go downstream: The new imperative in manufacturing. *Harv. Bus. Rev.* **1999**, *77*, 133–141.
76. Potts, G.W. Exploiting your product's service life cycle. *Harv. Bus. Rev.* **1988**, *66*, 32–36.
77. Kamp, B.; Parry, G. Servitization and advanced business services as levers for competitiveness. *Ind. Mark. Manag.* **2017**, *60*, 11–16. [\[CrossRef\]](#)
78. Porter, M.E. *Competitive Advantage: Creating and Sustaining Superior Performance*; The Free Press: New York, NY, USA, 1985.
79. Heskett, J.L. Lessons in the service sector. *Harv. Bus. Rev.* **1987**, *65*, 164–174.
80. Doni, F.; Corvino, A.; Martini, S.B. Servitization and sustainability actions. Evidence from European manufacturing companies. *J. Environ. Manag.* **2019**, *234*, 367–378. [\[CrossRef\]](#)
81. Szász, L.; Seer, L. Towards an operations strategy model of servitization: The role of sustainability pressure. *Oper. Manag. Res.* **2018**, *11*, 51–66. [\[CrossRef\]](#)
82. Khan, M.A.; Mittal, S.; West, S.; Wuest, T. Review on upgradability—A product lifetime extension strategy in the context of product service systems. *J. Clean. Prod.* **2018**, *204*, 1154–1168. [\[CrossRef\]](#)
83. Hojnik, J. Ecological modernization through servitization: EU regulatory support for sustainable product–service systems. *Rev. Eur. Comp. Int. Environ. Law* **2018**, *27*, 162–175. [\[CrossRef\]](#)
84. Corvellec, H.; Stål, H.I. Evidencing the waste effect of product-service systems (PSSs). *J. Clean. Prod.* **2017**, *145*, 14–24. [\[CrossRef\]](#)
85. Yang, M.; Evans, S. Product-service system business model archetypes and sustainability. *J. Clean. Prod.* **2019**, *220*, 1156–1166. [\[CrossRef\]](#)
86. Vezzoli, C.; Ceschin, F.; Diehl, J.C.; Kohtala, C. New design challenges to widely implement sustainable product-service systems. *J. Clean. Prod.* **2015**, *97*, 1–12. [\[CrossRef\]](#)
87. Mebratu, D. Sustainability and sustainable development: Historical and conceptual review. *Environ. Impact Assess. Rev.* **1998**, *18*, 493–520. [\[CrossRef\]](#)
88. Annarelli, A.; Battistella, C.; Nonino, F. Product service system: A conceptual framework from a systematic review. *J. Clean. Prod.* **2016**, *139*, 1011–1032. [\[CrossRef\]](#)
89. Moreno, R.; Marques, L.; Arkader, R. Servitization impact on performance moderated by country development. *Benchmarking Int. J.* **2019**, *27*, 302–318. [\[CrossRef\]](#)
90. Tseng, M.L.; Lin, S.; Chen, C.C.; Sarmiento, L.S.C.; Tan, C.L. A causal sustainable product-service system using hierarchical structure with linguistic preferences in the Ecuadorian construction industry. *J. Clean. Prod.* **2019**, *230*, 477–487. [\[CrossRef\]](#)
91. Porter, M.E.; Kramer, M.R. Creating Shared Value. How to reinvent capitalism—and unleash a wave of innovation and growth. *Harv. Bus. Rev.* **2011**, *89*, 2–17.
92. Chesbrough, H. Open innovation: A new paradigm for understanding industrial innovation. In *Open Innovation: Researching a New Paradigm*; Chesbrough, H., Vanhaverbeke, W., West, J., Eds.; Oxford University Press: New York, NY, USA, 2006; pp. 1–19.
93. Yin, R.K. *Case Study Research. Design and Methods*, 5th ed.; Sage Publications: Thousand Oaks, CA, USA, 2014.
94. Vendrell-Herrero, F.; Bustinza, O.F.; Parry, G.; Georgantzis, N. Servitization, digitization and supply chain interdependency. *Ind. Mark. Manag.* **2017**, *60*, 69–81. [\[CrossRef\]](#)

95. MacCarthy, B.L.; Lewis, M.; Voss, C.; Narasimhan, R. The same old methodologies? Perspectives on OM research in the post-lean age. *Int. J. Oper. Prod. Manag.* **2013**, *33*, 934–956. [[CrossRef](#)]
96. Larrinaga, O.V. Is it desirable, necessary and possible to perform research using case studies? *Cuad. Gest.* **2017**, *17*, 147–171. [[CrossRef](#)]
97. Hillebrand, B.; Kok, R.A.; Biemans, W.G. Theory-testing using case studies: A comment on Johnston, Leach, and Liu. *Ind. Mark. Manag.* **2001**, *30*, 651–657. [[CrossRef](#)]
98. De la Calle, A.; Alvarez, E.; Freije, I. Supply chain integration, a key strategic capability for improving product and service value propositions: Empirical evidence. *Int. J. Eng. Manag. Econ.* **2015**, *5*, 89–103. [[CrossRef](#)]
99. Freije, I.; de la Calle, A.; Ugarte, J.V. Role of supply chain integration in the product innovation capability of servitized manufacturing companies. *Technovation* **2021**, 102216. [[CrossRef](#)]
100. Grönroos, C. Value co-creation in service logic: A critical analysis. *Mark. Theory* **2011**, *11*, 279–301. [[CrossRef](#)]
101. Adrodegari, F.; Bacchetti, A.; Sacconi, N.; Arnaiz, A.; Meiren, T. The transition towards service-oriented business models: A European survey on capital goods manufacturers. *Int. J. Eng. Bus. Manag.* **2018**, *10*, 1–10. [[CrossRef](#)]
102. Cenamor, J.; Sjödin, D.R.; Parida, V. Adopting a platform approach in servitization: Leveraging the value of digitalization. *Int. J. Prod. Econ.* **2017**, *192*, 54–65. [[CrossRef](#)]
103. Chen, J.S.; Kerr, D.; Tsang, S.S.; Sung, Y.C. Co-production of service innovations through dynamic capability enhancement. *Serv. Ind. J.* **2015**, *35*, 96–114. [[CrossRef](#)]
104. Koufteros, X.; Vonderembse, M.; Jayaram, J. Internal and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy. *Decis. Sci.* **2005**, *36*, 97–133. [[CrossRef](#)]
105. Cheng, Y.; Chaudhuri, A.; Farooq, S. Interplant coordination, supply chain integration, and operational performance of a plant in a manufacturing network: A mediation analysis. *Supply Chain Manag. Int. J.* **2016**, *21*, 550–568. [[CrossRef](#)]
106. Witell, L.; Löfgren, M. From service for free to service for fee: Business model innovation in manufacturing firms. *J. Serv. Manag.* **2013**, *5*, 520–533. [[CrossRef](#)]
107. Visnjic, I.; Wiengarten, F.; Neely, A. Only the brave: Product innovation, service business model innovation, and their impact on performance. *J. Prod. Innov. Manag.* **2016**, *33*, 36–52. [[CrossRef](#)]
108. Beuren, F.H.; Ferreira, M.G.G.; Miguel, P.A.C. Product-service systems: A literature review on integrated products and services. *J. Clean. Prod.* **2013**, *47*, 222–231. [[CrossRef](#)]
109. Vifell, Å.C.; Soneryd, L. Organizing matters: How ‘the social dimension’ gets lost in sustainability projects. *Sustain. Dev.* **2012**, *20*, 18–27. [[CrossRef](#)]
110. Lafuente, E.; Vaillant, Y.; Vendrell-Herrero, F. Territorial servitization: Exploring the virtuous circle connecting knowledge-intensive services and new manufacturing businesses. *Int. J. Prod. Econ.* **2017**, *192*, 19–28. [[CrossRef](#)]
111. Mpinganjira, M.; Roberts-Lombard, M.; Svensson, G. Validating the relationship between trust, commitment, economic and non-economic satisfaction in South African buyer-supplier relationships. *J. Bus. Ind. Mark.* **2017**, *32*, 421–431. [[CrossRef](#)]
112. Gölgeci, I.; Gligor, D.M.; Lacka, E.; Raja, J.Z. Understanding the influence of servitization on global value chains: A conceptual framework. *Int. J. Oper. Prod. Manag.* **2021**, 1–23. [[CrossRef](#)]
113. Castelló, I.; Lozano, J.M. Searching for new forms of legitimacy through corporate responsibility rhetoric. *J. Bus. Ethics* **2011**, *100*, 11–29. [[CrossRef](#)]