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Developing PSS business ecosystems in the digital era

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Abstract:	This paper presents two approaches to developing PSS (product-service systems) business ecosystems for manufacturing and service organisations by leveraging digital development. Our research is based on two in-depth, comparative case studies of large multinational corporations: one manufacturing company that takes the servitisation approach and the other a logistics services company taking a productisation approach. The research addresses two principal gaps in extant PSS research. First, most extant PSS research focuses predominantly on servitisation development and overlooks the productisation perspective. We address this gap by considering PSS from both a productisation and servitisation perspective. Second, extant research investigates PSS integration mainly from the 'technical' and 'commercial' perspectives. In contrast, this research adds a 'social' perspective by considering the business-to-authority (B2A) and business-to-public (B2P) relations. The findings also provide business practitioners with preliminary yet meaningful insights into holistic consideration of PSS ecosystem integration from 'technical', 'commercial' and 'social' perspectives. Moreover, we seek to push the boundaries of PSS ecosystem research and promote interdisciplinary research across fields, including business strategy, industrial marketing, social marketing, public policy and supply chain management.

Suggested Reviewers:	Nicholas Rich Professor in Operations Management, Swansea University School of Management n.l.rich@swansea.ac.uk Expert in systems thinking and practice, including socio-technical systems.
	Paul Walley, PhD Director of Learning, The Open University Business School paul.walley@open.ac.uk Expert in Operations Management in both manufacturing and service settings.
Opposed Reviewers:	
Response to Reviewers:	The response to reviewers and cover letter are attached as separate files.

Dear Professor Di Benedetto,

Thank you very much for evaluating the third iteration of our manuscript titled 'Developing PSS business ecosystems in the digital era' and for providing us with the opportunity to further strengthen our paper. We acknowledge the additional comments made by Reviewer 1 and have done our best to amend our manuscript in line with them. Attached you will find our response to the points that were raised by the reviewer as well as the revised manuscript.

We hope the revised version of the paper now meets the expectations for publication in Industrial Marketing Management.

Wishing you all the best for the new year.

Kind Regards

Ai Qiang Li, The University of Buckingham, UK

Andrew Lahy, The University of Buckingham, UK

Pauline Found, Cardiff University, UK

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Observation	Reviewer #1:	Response
	The current version of the paper, that has been accurately revised according to the reviewers' comments, is significantly improved in respect to the scientific rigor as well as to the quality of the contribution of this research. All the observations I made in reviewing the first version have been intelligently addressed without altering the structure of the paper. I agree on most of the choices that the author(s) has/have made. The integration of new contents (and the choice of removing less relevant arguments) prove now an effective new read. Section 5 clearly highlights the most significant contributions (summarized in Table 6). The logic used to connect the literature (now expanded and consolidated in a new research framework), the empirical material, the results and the discussion is actually much more consistent. I also appreciated the discussion of the social component of ecosystem development in servitization and productisation, that now emphasises what is in my view the main contribution of this research, i.e. shedding light on the "company's ability to engage with B2A and B2P stakeholders" in the intercourse of productization or servitization strategies and transformations. I believe the paper is acceptable for publication. Below only a couple of minor comments that can be easily addressed.	Thank you very much for your second review and recommendation for acceptance of the revised manuscript. We appreciate your recognition of the improvements that we have made to the manuscript and the contribution that it now makes to the extant literature. We have revised the paper following your last observations. Your insightful and comprehensive comments have been invaluable in improving our paper and were greatly appreciated!
1	Some anticipations about limitations and avenues of future research are placed in Section 5 (e.g. "However, only two case companies limit the generalisation of findings. Thus, more comparative case studies are strongly recommended for future research, for example on studying the co-evolvement and interactions between performance-oriented integration and experience-oriented integration."). I suggest to remove similar considerations of Section 5, since they are better argumented in Section 6.	Thank you for this observation. We agree, the limitations and future research areas that were previously discussed in Section 5, could indeed better be included in Section 6. We have revised Section 5 and found five statements about research limitations and future research areas. We have removed these now from Section 5 and embedded them in Section 6. The changes are highlighted in blue on pages 26-28 and 31-32.
2	In the discussion about promising research avenues, I would suggest to include some considerations related to the needs of exploring better how the results coming from PSS ecosystems social integration could influence both the mentioned PSS technical and commercial choices, dictating the expected benefits of more sustainable PSS (in particular, in terms of social and environmental benefits.	Thank you very much for this suggestion. Indeed the interplay and mutual-impact between the technical, commercial, and social integration is an important and interesting area for future research. In recognition of this we have this now added to the last paragraph (Pages 31-32). We have highlighted the section for easy identification.

Highlights

- The development of PSS business ecosystems can be realised by both manufacturing and service organisations through servitisation and productisation
- PSS ecosystem integration requires holistic consideration from ‘technical’, ‘commercial’, and ‘social’ perspectives
- Business to authority (B2A) and business to public (B2P) relations emerge in PSS ecosystems
- The research promotes interdisciplinary collaboration across fields including business strategy, industrial marketing, social marketing, public policy and supply chain management

Abstract

This paper presents two approaches to developing PSS (product-service systems) business ecosystems for manufacturing and service organisations by leveraging digital development. Our research is based on two in-depth, comparative case studies of large multinational corporations: one manufacturing company that takes the servitisation approach and the other a logistics services company taking a productisation approach. The research addresses two principal gaps in extant PSS research. First, most extant PSS research focuses predominantly on servitisation development and overlooks the productisation perspective. We address this gap by considering PSS from both a productisation and servitisation perspective. Second, extant research investigates PSS integration mainly from the 'technical' and 'commercial' perspectives. In contrast, this research adds a 'social' perspective by considering the business-to-authority (B2A) and business-to-public (B2P) relations. The findings also provide business practitioners with preliminary yet meaningful insights into holistic consideration of PSS ecosystem integration from 'technical', 'commercial' and 'social' perspectives. Moreover, we seek to push the boundaries of PSS ecosystem research and promote interdisciplinary research across fields, including business strategy, industrial marketing, social marketing, public policy and supply chain management.

Keywords Ecosystem Integration, Servitisation, Productisation, Digitalisation, Decarbonisation, B2A, B2P

Developing PSS business ecosystems in the digital era

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** Pauline, Maneesh and Bjorn have equal contributions to the paper.

Developing PSS business ecosystems in the digital era

Abstract

This paper presents two approaches to developing PSS (product-service systems) business ecosystems for manufacturing and service organisations by leveraging digital development. Our research is based on two in-depth, comparative case studies of large multinational corporations: one manufacturing company that takes the servitisation approach and the other a logistics services company taking a productisation approach. The research addresses two principal gaps in extant PSS research. First, most extant PSS research focuses predominantly on servitisation development and overlooks the productisation perspective. We address this gap by considering PSS from both a productisation and servitisation perspective. Second, extant research investigates PSS integration mainly from the 'technical' and 'commercial' perspectives. In contrast, this research adds a 'social' perspective by considering the business-to-authority (B2A) and business-to-public (B2P) relations. The findings also provide business practitioners with preliminary yet meaningful insights into holistic consideration of PSS ecosystem integration from 'technical', 'commercial' and 'social' perspectives. Moreover, we seek to push the boundaries of PSS ecosystem research and promote interdisciplinary research across fields, including business strategy, industrial marketing, social marketing, public policy and supply chain management.

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1. Introduction

The boundaries between manufacturing and service-orientated organisations are increasingly blurred, particularly with the impact of digitalisation on strategies and business models. This presents both challenges and opportunities for businesses to stay competitive and grow. Business practitioners must find ways to compete with known rivals in the same industry and new entrants from the same or, increasingly, other industries (Porter and Heppelmann, 2014, 2015; Vandermerwe and Rada, 1988). As a result, manufacturing and service firms are reshaping their strategies and business models away from a sell-buy transaction of products or services to the development of integrated product-service systems (PSS) (Baines *et al.*, 2007; Gaiardelli *et al.*, 2021). The leveraging of digital technologies such as the Internet of Things (IoT), cloud computing and big data analytics (Gaiardelli *et al.*, 2021; Gebauer *et al.*, 2021; Rabetino *et al.*, 2021) has also enabled the transformation further into PSS business ecosystems.

The future expansion of 5G networks also accelerates the digital technologies and opportunities available to firms (Shafique *et al.*, 2020) to develop PSS business ecosystems. A business ecosystem is defined as 'an economic community where a group of interacting firms beyond the boundaries of a single industry mutually adapt and coevolve their capabilities and roles to build a shared vision, set governance rules, and gain sustainable competitive advantage' (Li *et al.*, 2022, p. 289). Over time, the members align themselves with the direction set by one or more central companies (Moore, 1996). These central organisations are considered ecosystem leaders and aim to integrate various product and service offerings from other complementary organisations. Organisations seeking to be PSS ecosystem leaders have taken two distinct approaches.

First, the servitisation approach. In this case, manufacturers add or embed services to physical products, such as digital services, within a 'smart connected product' (Porter and Heppelmann, 2014, 2015). For example, John Deere, Siemens and Electrolux have integrated various types of services with their product offerings to develop Smart Farm, Smart City and Smart Home ecosystems, respectively, and Toyota has been transforming itself from a car maker into a Smart Mobility ecosystem provider (Toyota, 2019). Second, the productisation approach, in which service-based organisations develop and add physical products to their service offerings or bundle their services with physical products (Davies, 2004; Davies *et al.*, 2006; Lahy *et al.*, 2018). In the productisation literature, there are two streams: the first one discusses a rather general process where relevant elements are combined into product-like objects, and the other is discussed as a reverse approach to servitisation (Harkonen, 2021). We take the latter stream in this paper. For example, Google and Amazon have developed and integrated Nest devices and Echo & Ring devices to become Smart Home ecosystem leaders.

PSS development from the perspectives of both manufacturing-oriented and service-based organisations opens up possibilities for more holistic research into the development of PSS ecosystems (Gaiardelli *et al.*, 2021; Paschou *et al.*, 2020). Although several studies have attempted to investigate PSS from this broad ecosystem perspective (e.g. the work of Burström et al. (2021) and Gaiardelli et al. (2021)), many studies have primarily focused on the servitisation perspective, largely overlooking the alternative productisation approach (Lahy *et al.*, 2018; Leoni, 2019; Li *et al.*, 2022). Comparable studies from both perspectives are rare, and scholars are thus highly encouraged to close the gap (Li *et al.*, 2022). This paper redresses this balance by considering both perspectives. To address the above gaps, we identify two streams of investigation.

First, in the field of PSS, product and service integration is considered a key success factor and thus highly relevant for scholars and practitioners (Gebauer *et al.*, 2013; Rabetino *et al.*, 2018, 2021; Shankar *et al.*, 2009; Ulaga and Reinartz, 2011). However, current research on supply chain integrations should shift from a traditional linear chain perspective into a more holistic network, circular, and ecosystem perspective (Burström *et al.*, 2021; Ellram and Murfield, 2019; Stahel, 2016). This is because integrations of products and services in PSS ecosystems go beyond the traditional transaction and vertical relational set-up and involve more horizontal, integrated relations (Gaiardelli et al., 2021; Li et al., 2022). The urgent need to develop environmentally sustainable supply chains also demands a shift from linear to circular thinking (Stahel, 2016). The links between sustainable, circular supply chains and PSS business models are already well established (Mont, 2002; Yang *et al.*, 2018). Hence, in this paper, we do not concentrate too much on the topic of circularity. Instead, we focus on the increasing interconnection and interaction enabled by digitalisation, and on the access and involvement of emerging actors such as regulatory agencies, the public and end users, and their developing role in contributing to the PSS ecosystem integration in particular (Bulut and Anderl, 2022; Liedtke *et al.*, 2015). For example, as authorities and policymakers emerge in defining supportive ecosystem policies and standards that apply to both products and services, the business-to-authority (B2A) relations will warrant more attention from researchers and academia, as Burström *et al*. (2021) highlight in their research.

Second, extant literature investigates PSS integrations mainly from a 'technical' perspective and a 'commercial' perspective. For example, research on 'technical' integration includes PSS design and engineering (Manzini and Vezzoli, 2003; Matschewsky *et al.*, 2018; Morelli, 2002; Qu *et al.*, 2016), vertical and horizontal integrations (Baines and Lightfoot, 2013; Davies, 2004; Gebauer *et al.*, 2013) and digital capabilities (Ardolino *et al.*, 2017; Kamalaldin *et al.*, 2020; Lenka *et al.*, 2017). Research on 'commercial' integration includes commercial strategies such as in-house development and acquisition (Baines *et al.*, 2013; Davies, 2004; Gebauer *et al.*, 2013; Mathieu, 2001) and business models such as outcome-based contract and performance-based logistics (Holmbom *et al.*, 2014; Ng *et al.*, 2013; Visnjic *et al.*, 2017). In doing so, it overlooks considering PSS ecosystem integrations from a 'social' perspective, such as B2A and B2P (business-to-public) relations. However, the 'social' perspective is imperative considering the blooming of interconnectivity, service experience and awareness of social responsibility that increasingly impact business decisions, for example, in the areas of decarbonisation and governmental environmental tax and legislation. Moreover, in a world of social influencers and social media, businesses can no longer ignore the influence of B2P

stakeholders. For example, social influencers share information to change attitudes and affect prospective buyers' decision outcomes (Agnihotri and John-Mariadoss, 2022; Cartwright *et al.*, 2022; Neuhaus *et al.*, 2022). While social influencers may not be the consumers of the product or service, their influence may affect what products or services consumers buy. Social media is also changing how ecosystem relationships are developed (Corsaro and Maggioni, 2022), which can be crucial to PSS ecosystem integration. A clear example of the influence of B2A and B2P can be found in the automotive sector, where B2A and B2P actors encourage consumers to select non-fossil fuel-powered transportation or even public transport or shared cycle schemes. The emerging ecosystems in response to these pressures are examples of ecosystems that seek to address environmental as well as commercial objectives.

Based on the above two streams of investigation and the extant gaps, in this paper, we work towards closing these gaps and seek to answer the following research question:

How do organisations, whether through a servitisation or productisation approach, manage the development and integration of a PSS ecosystem from technical, commercial and social perspectives and considering B2B, B2P and B2A stakeholders?

To address this question, we analysed two comparative case studies in multinational corporations (MNCs): one global manufacturing company moving into a Smart Port ecosystem via a servitisation approach and one global logistics services company adding manufacturing capabilities via a productisation approach. The findings from these case studies seek to advance our understanding of the emerging PSS business ecosystems from two opposite approaches (i.e., servitisation and productisation). The findings provide business practitioners with preliminary yet meaningful insights into developing PSS business ecosystems by holistic consideration of PSS integration from 'technical', 'commercial' and 'social' perspectives. In particular, business practitioners are advised to consider engaging with B2A and B2P stakeholders. Our research also responds to the call for interdisciplinary research in industrial marketing (Lindgreen *et al.*, 2020; Markovic *et al.*, 2021) by integrating ideas and perspectives from different disciplines, including strategy, industrial marketing, social marketing, public policy and supply chain management.

The remainder of this paper is structured as follows. Section 2 provides an overview of the key literature associated with our research question to ensure we build upon existing knowledge and ideas. Section 3 introduces the research methodology. Section 4 presents our findings. Section 5 discusses the findings, followed by Section 6, which provides the conclusion and potential avenues for future research.

2 Background Literature

In this section, we will provide a comprehensive overview of the background literature. As PSS ecosystems embrace several research areas, we include the following keywords in the literature search: 'business ecosystems', 'PSS', 'product-service system', 'integrations', 'servitisation', 'productisation', 'service systems', 'business-to-authority (B2A)' and 'business-to-public (B2P)'. The comprehensive synopsis of the literature allows us to justify the gaps, which will be summarised at the end of this section.

2.1 The evolution of PSS business ecosystems

PSS business ecosystems have emerged from the development of PSS and digitalisation in the era of Industry 4.0 (Burström *et al.*, 2021; Gaiardelli *et al.*, 2021; Li *et al.*, 2022). In their literature review on PSS, Li *et al.* (2020) summarise a three-phase PSS development. The first phase (1999-2004) set the foundation for concept development with main concerns on environmental sustainability and related governmental policy. The second phase (2005-2008) was characterised by reflecting and adjusting PSS research directions, such as questions arising from service paradox (Brax, 2005; Gebauer *et al.*, 2005). In the ongoing third phase that is interwoven with digitalisation, industry boundaries increasingly expand beyond product systems towards systems of systems. As a result, the competitive landscape shifts away from the functionality of a discrete product or service towards the performance of broader systems, as businesses offer packages of integrated products and services that optimise overall performance (Porter and Heppelmann, 2014). Both from an industry and government regulation perspective (e.g., COP26 and EU Fit for 55), the third phase also reinforces the focus of the first phase, with its current focus on decarbonisation and climate-neutrality. To succeed, PSS providers must engage a broad group of partners to allow them to integrate their related products (e.g., environmental compliance products) and services (especially digital services that enable environmental compliance) into their PSS ecosystems to deliver financial and environmental performance benefits.

Most research on PSS has focused on manufacturing organisations adding services (servitisation), and only a few pay attention to service organisations integrating physical products (productisation) (Davies *et al.*, 2006; Lahy *et al.*, 2018; Leoni, 2015). As illustrated by Tukker's framework (Fig.1), PSS can be achieved through servitisation and productisation. In other words, PSS is achievable for both manufacturing and service organisations (Lahy *et al.*, 2018). Indeed, there are many instances in which service organisations add tangible products to create a commercially viable PSS. Examples include Amazon's success in

developing a PSS by starting with a service offering (webshop) and then adding physical products (Kindle, Echo and Ring devices); Google's attempt to develop self-driving cars (now under Alphabet), mobile phones, and Nest devices. Ultimately, they all aim to add a tangible product within a PSS business ecosystem. As both manufacturing-oriented and service-based MNCs are diversifying in products and service offerings, a better understanding of how to manage both business orientations, not as two standalone business units, but as one integrated PSS and within a canvas of broad PSS ecosystem, is critical for success.

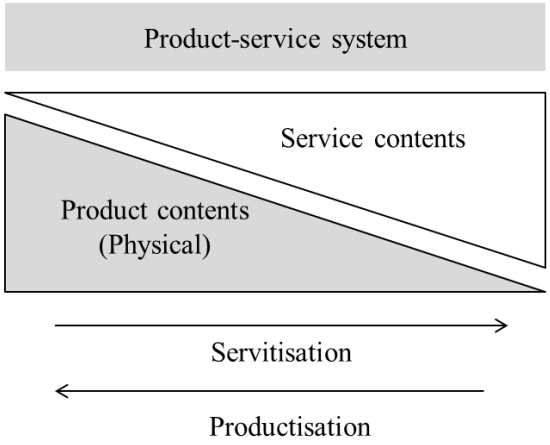

Fig.1 The evolution to PSS: adapted from Tukker (2004) and Lahy *et al.* (2018)

2.2 Integrations in PSS business ecosystems

The development and delivery of PSS ecosystems require complex integrations of multiple products and services from many actors, including component manufacturers, sub-system integrators, service providers, and complementary partners (Gebauer *et al.*, 2013; Sklyar *et al.*, 2019; Ulaga and Reinartz, 2011). For many firms, the biggest challenge to developing a PSS business model is integrating different tangible and intangible elements, often from external sources (Davies, 2004; Li, Rich, *et al.*, 2020). Literature on PSS integrations can be mainly grouped into two categories: integrations from a technical perspective (technical integrations) and integrations from a commercial perspective (commercial integrations). Technical integration involves designing, engineering, and structuring different elements such as products, services, and digital infrastructure. Commercial integration is about integrating product and service offerings, financial incentives, and marketing channels. There is also a call for research on a third social perspective, i.e., social integration that deals with social relationships, public awareness and user experience (Li, Rich, *et al.*, 2020; Zhang *et al.*, 2017).

Regarding the resources and capabilities necessary for PSS integrations, four main development strategies, i.e., inhouse development (make), buy (acquisition), joint venture and partnership are frequently discussed in the literature (Baines and Lightfoot, 2013; Davies, 2004; Gebauer *et al.*, 2013; Mathieu, 2001). They apply to technical and commercial integrations, which will be discussed in detail in the following sections.

2.2.1 Integrations from a technical perspective

As research on PSS largely centres on how manufacturers integrate services with their existing products (i.e., the servitisation approach), a large group of scholars study PSS integrations in terms of design and engineering (Manzini and Vezzoli, 2003; Matschewsky *et al.*, 2018; Morelli, 2002; Qu *et al.*, 2016). Consequently, the focus is on design methodologies and configuring frameworks for integrating physical products with different types or levels of services, such as the eight types of PSS by Tukker (2004) and three types of services (base services, intermediate services and advanced services) by Baines and Lightfoot (2013). Morelli (2002) argues that a PSS is the result of interactions between different actors and technological elements during the use phase, meaning that design activities should emphasise convergence between several social and technological factors. Several scholars have started to design PSS from a socio-technical systems perspective (Li, Rich, *et al.*, 2020; Liedtke *et al.*, 2015).

Other scholars focus on PSS integrations from a vertical and horizontal perspective. Vertical integration refers to the combination of sequential processes along with the production flow at different hierarchical levels (Gebauer *et al.*, 2013). From a PSS development perspective, the research considers the opportunities of upstream (backward) integration towards sources of supply by taking over suppliers' activities and downstream (forward) integration towards marketing or distribution by taking control of activities carried out by customers (Baines and Lightfoot, 2013; Davies, 2004; Gebauer *et al.*, 2013). With the trend of 'go downstream' to end users through services (Davies, 2004; Schmenner, 2009; Wise and Baumgartner, 1999), manufacturing-oriented organisations increasingly integrate activities that are previously handled in-house by customers or customers' other service partners (Davies, 2004; Gebauer *et al.*, 2013). In contrast, service-based organisations would need to seek to strengthen their upstream capabilities of designing and integrating physical products but can also move further downstream by providing services previously carried out by their sub-contractors or customers (Davies, 2004).

Horizontal integration refers to the combination of two or more organisations that are at the same level or in the same stage of production (Davies, 2004; Gebauer *et al.*, 2013). When

moving to broader ecosystems, PSS providers must go beyond vertical integrations in search of more products and services from many complementary partners. Furthermore, with digital development blurring industry boundaries, new actors emerge from seemingly unrelated industries to contribute to ecosystem integration (Porter and Heppelmann, 2014; Sklyar *et al.*, 2019). Consequently, the integrations require PSS providers to shift from a traditional linear chain perspective into a more holistic ecosystem perspective (Burström *et al.*, 2021; Gaiardelli *et al.*, 2021; Li *et al.*, 2022).

Regarding the development strategies, literature indicates that product-centred organisations tend to choose in-house technical development when seeking to add advanced services and integration capabilities (Bustinza *et al.*, 2019; Davies, 2004). Alternatively, service-based companies are more likely to establish a partnership for technical integration or acquire access to develop complementary products. This is primarily due to product-centred organisations considering their technical knowledge and skills as a core competence and source of differentiation. As such, they consider the knowledge as intellectual capital to be protected (Kianto *et al.*, 2010; Lenka *et al.*, 2018). By contrast, service-based organisations centre on people and relationships (Lenka *et al.*, 2018; Levitt, 1983) and are more open to partnerships for technical integration as this is often their source of differentiation and competitive advantage. A second reason for manufacturers to choose in-house development is to take advantage of the benefits of dynamic feedback loops between product and service divisions for improving overall systems performance (Davies, 2004).

2.2.2 Integrations from a commercial perspective

As the development and delivery of PSS ecosystem offerings are from various actors, commercial integrations are required to define terms and conditions, roles and responsibilities, benefit/risk sharing schemes, and accessing and controlling marketing channels. Acquisition and strategic partnership are frequently discussed in the literature on commercial integrations of PSS (Davies, 2004; Kamalaldin *et al.*, 2020; Kowalkowski *et al.*, 2017; Reinartz and Ulaga, 2008). For example, manufacturing-oriented organisations may need to acquire new digital capabilities, such as big data analytics, that product providers would traditionally not offer (Kamalaldin *et al.*, 2020; Porter and Heppelmann, 2014). Similarly, service-based organisations may require integration capabilities to design, assemble and install equipment sourced from other manufacturers (Davies, 2004; Lahy *et al.*, 2018).

PSS providers via servitisation also innovate in business models such as the outcome-based contract (OBC) and performance-based logistics (PBL). In line with the result-oriented

services (Tukker, 2004), OBC or PBL is a contracting mechanism that allows the buyer to pay only when the provider has delivered agreed outcomes/performances. In this model, the supplier offers a combination of products and related services to deliver an outcome, and the supplier is then awarded according to the level of system performance, such as availability (Batista *et al.*, 2017; Dmitrijeva *et al.*, 2022; Holmbom *et al.*, 2014; Ng *et al.*, 2009). OBC and PBL are the results of commercial integrations, including integrations of product/service offerings, roles and responsibilities, incentives and risks between the supplier and the customer. In such cases, as PSS providers take over operational activities from the customers, they have a financial incentive to design systems from the start that are reliable and easily maintainable (Davies, 2004; Dmitrijeva *et al.*, 2022). These contracting mechanisms may also seek to promote the identification and delivery of co-creation opportunities and specify sharing of savings between the PSS provider and the customer. With this, to identify possibilities for service improvement and cost reductions and have an aligned, integrated commercial mechanism to share them, the customer and the provider need to collaborate and have appropriate incentives (Li *et al.*, 2022; Plepys *et al.*, 2015).

2.2.3 Integrations from a social perspective

Perhaps because of the focus of PSS researchers on the possibilities for manufacturing-oriented organisations, where a tangible product forms the basis for the development of a PSS, much extant PSS research focuses more on technical integrations than social integrations. Social integration means developing PSS integrations by embracing other social actors such as government authority, the public and end consumers and shifting to experience-centred thinking. For manufacturing and service-based firms, shifting to a PSS business model often requires companies to manage relationships with many different actors. These external actors can act as either a driving (enabling) force or a restraining force to successfully develop and deliver a PSS (Lahy *et al.*, 2018). In particular, governmental agencies and public policymakers play an essential role in enabling or restraining PSS development (Amor *et al.*, 2018; Mont and Lindhqvist, 2003; Plepys *et al.*, 2015). Legislation can also act as a restraining force, inhibiting organisations from developing PSS business models (consider government legislation blocking shared-use mobility scooters in certain cities).

Sweden provides an example of where government regulation can enable PSS development. With this, a PSS was partially accomplished through policy support from the Swedish EPA (Environmental Protection Agency) functional programme. Governmental support for PSS development can include research and dissemination of knowledge, facilitation of demonstration and pilot projects in new areas through direct R&D support, and risk sharing

with financial institutions (Mont and Lindhqvist, 2003). Policy measures such as taxes and EPR (extended producer responsibility) programmes will also 'help to shift out environmentally inferior solutions, leaving economically viable and environmentally sound PSSs on the market' (Mont and Lindhqvist, 2003, p. 912). The roles of governmental agencies and public policymakers can be vital in shaping and defining supportive ecosystem policies and standards when PSS providers move into broader PSS ecosystems. Therefore, like Burström *et al*. (2021), we argue that B2A relations should receive more academic attention when considering PSS ecosystem development.

The literature also shows that public policy initiatives that support a broader supply and demand of PSS solutions can be seen on different government levels, from international bodies, such as the European Union, to local member states and municipal cities. Generally, policy actions on the local level are more likely to support the roll-out of PSS solutions into society than those on the national or international levels (Plepys *et al.*, 2015). PSS solutions receiving policy support are often those that provide clear economic, environmental or social benefits on the local level. If there are strong environmental or social benefits but weak commercial incentives for new PSS businesses to emerge and prevail, policy intervention is needed to create competitive conditions for the new solutions to stand a fair chance (Plepys *et al.*, 2015).

Similar to the business to consumer (B2C) marketing, where informed, networked, empowered, and active consumers are increasingly co-creating value with the organisation and shifting to experience (Prahalad and Ramaswamy, 2004), B2B marketing also requires social interactions with other actors such as government authority, the public and consumers. The enhanced digital connectivity via 'smart connected products' (Porter and Heppelmann, 2014, 2015) and 'smart services' (Kagermann *et al.*, 2014) is changing the socialisation process by connecting many actors into one platform through instant dialogue and access to data and insights. The socialisation process leads to more decentralised and democratised social interactions such as B2P interactions that centre on awareness and experience. Regarding research in the B2P field, social media research has attracted increasing interests from B2B marketing academics and practitioners working on strategy, branding, marketing and sales (Cartwright and Davies, 2022; Kumar and Sharma, 2022; Salo, 2017). Research shows social media is changing the way ecosystem relationships are developed, reducing cold calls and increasing brand visibility and popularity (Corsaro and Maggioni, 2022). Embracing social media can enable sales organisations to remain competitive in a socially connected business environment (Agnihotri and John-Mariadoss, 2022). The use of social influencers can change attitudes and affect prospective buyers' decision outcomes (Agnihotri and John-Mariadoss,

2022; Cartwright *et al.*, 2022; Neuhaus *et al.*, 2022). For example, social awareness and public perception of decarbonisation and environmental sustainability can impact B2B decision-making on selecting sustainable products, services, and PSS business models. New insights can also be derived from integrating internal and external data, which are delivered in real-time thanks to social platforms (Corsaro and Maggioni, 2022). Consequently, salespeople's use of social media can enhance their social capital for value co-creation (Itani *et al.*, 2022), which can be a crucial factor for PSS ecosystem integration.

The key literature reviewed in this research is summarised in Table 1.

Table 1 Summary of background literature

Authors	Scope of study	Path (Servitisation/productisation)	Perspective of integration	B2A	B2P
Agnihotri and John-Mariadoss (2022)	/	/	A social perspective	/	✓
Bulut and Anderl (2022)	Ecosystem	Servitisation	A technical perspective	/	/
Cartwright *et al.* (2022)	/	/	A social perspective	/	✓
Corsaro and Maggioni (2022)	Ecosystem	/	A social perspective	/	✓
Li *et al.* (2022)	Ecosystem	Servitisation	A technical/commercial perspective	✓	/
Kumar and Sharma (2022)	/	/	A social perspective	/	✓
Burström *et al.* (2021)	Ecosystem	Servitisation	A technical perspective	/	/
Gaiardelli *et al.* (2021)	Ecosystem	Servitisation	A technical perspective	/	/
Kamalaldin *et al.* (2020)	Dyadic relationship	Servitisation	A technical perspective	/	/
Tronvoll *et al.* (2020)	Network	Servitisation	A social perspective	/	✓
Sklyar *et al.* (2019)	Ecosystem	Servitisation	A social perspective	✓	/
Lahy *et al.* (2018)	Network	Productisation	A technical perspective	/	/
Lenka *et al.* (2017)	Dyadic relationship	Servitisation	A technical perspective	/	/
Zhu and Furr (2016)	Platform	/	A commercial perspective	/	/
Plepys *et al.*(2015)	/	Servitisation	A social perspective	✓	/
Porter and Heppelmann (2015)	Ecosystem	Servitisation	A technical/commercial perspective	/	/
Leoni (2015, 2019)	/	Servitisation and Productisation	/	/	/
Baines and Lightfoot (2013)	Triadic relationship	Servitisation	A technical perspective	/	/
Gebauer *et al.* (2013)	Network	Servitisation	A technical perspective	/	/
Martinez *et al.* (2010)	Dyadic relationship	Servitisation	A technical perspective	/	/
Davies (2004)	Network	Servitisation and Productisation	A technical perspective	/	/
Mont and Lindhqvist (2003)	/	Servitisation	A social perspective	✓	/
Oliva and Kallenberg (2003)	Dyadic relationship	Servitisation	A technical perspective	/	/
Vandermerwe and Rada (1988)	Network	Servitisation	A technical/commercial perspective	/	/

2.3 The research gaps

From the literature reviewed above, two principal gaps are identified.

First, many business cases exist where service-based organisations such as Amazon and Google develop PSS business ecosystems via productisation. However, extant research on PSS is mainly from a servitisation perspective, and only limited studies attempt to investigate PSS from a productisation perspective. Moreover, scarcely any research explores PSS business ecosystems from both perspectives, which inhibits business practitioners and academia from having a holistic view of understanding and developing PSS business ecosystems.

Second, extant literature investigates PSS integrations mainly from 'technical' and 'commercial' perspectives and overlooks integrations from a 'social' perspective. Comprehensive research from 'technical', 'commercial' and 'social' perspectives is rare. With the shift into PSS business ecosystems and value co-creation leveraged by enhanced digital connectivity that aims to deliver an optimised performance result (Gaiardelli *et al.*, 2021; Li *et al.*, 2022), PSS ecosystem integrations increasingly involve more 'social' integrations of B2A and B2P relations.

Moreover, research on PSS business ecosystems requires an interdisciplinary view. The literature suggests that although PSS research is often undertaken from various academic disciplines, including strategy, marketing, sustainability, service science, management, design, engineering, and information systems, there is a lack of interdisciplinary collaboration and research (Li, Kumar, *et al.*, 2020). Such a lack hinders the formation of a holistic overview. For example, in their research analysing more than 1000 articles and references related to servitisation, Rabetino *et al.* (2018) found that the number of papers co-authored by scholars from different disciplines is low, and about 70 per cent of the references belong to the same discipline. As B2B research is inherently cross-disciplinary, involving economics, psychology, sociology, and management disciplines (Lindgreen *et al.*, 2020), interdisciplinary research is necessary when PSS evolves into broader ecosystems. This will break down silos in academia and brings in new and cross-discipline ideas, methods, and theories that are essential and inspirational for understanding and developing PSS business ecosystems. As a result, further interdisciplinary research is encouraged to break down domain silos (Markovic et al., 2021)

Finally, a conceptual framework of PSS ecosystem integration is constructed by embracing various fields of literature, as illustrated in Fig.2. The framework considers both the productisation and servitisation perspectives of PSS development through horizontal and

vertical integrations. The integrations are considered from technical, commercial, and social perspectives.

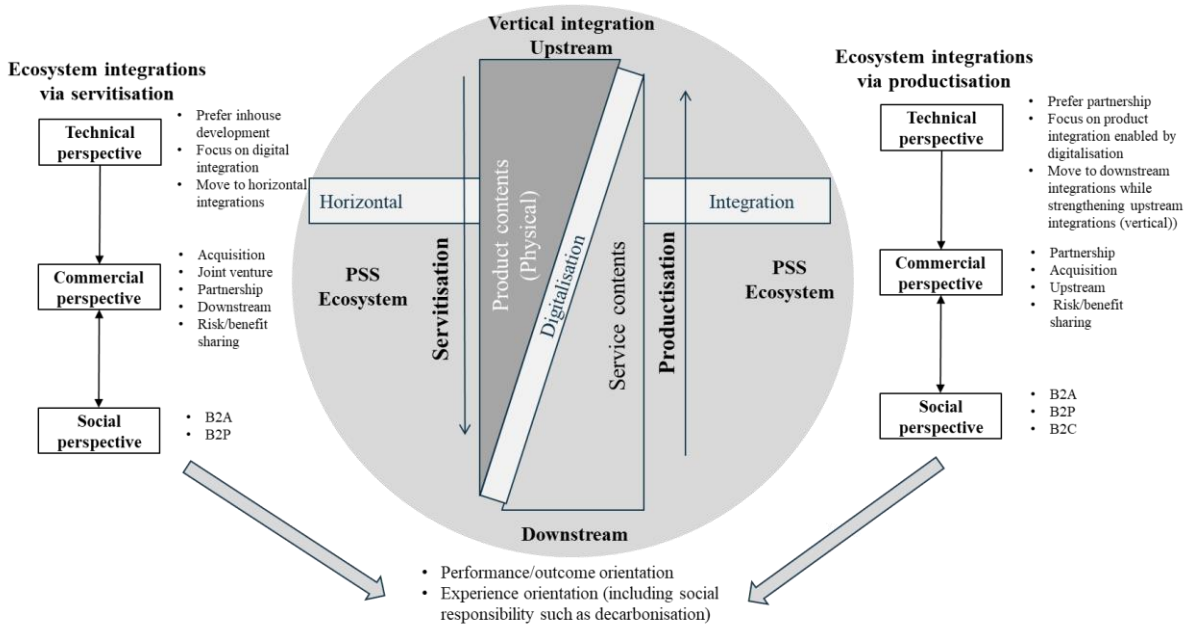

Fig.2 A conceptual framework of PSS ecosystem integration

3 Methodology

It was elected to use a qualitative case study design for this research, as investigations into PSS business ecosystems is considered a contemporary phenomenon in a real-life context, and qualitative case studies can provide rich and in-depth information that cannot be obtained by other methods such as experimental and survey strategies (Eisenhardt, 1989; Yin, 2009). Case studies are widely used in industrial marketing (Easton, 2010; Jaakkola and Hakanen, 2013; Kamalaldin *et al.*, 2020). This important methodological choice is because "the main units of analysis are organisations and relationships, which are difficult to access, and complex in structure compared *with, for example, consumer markets. As a result, a case study … provides a great deal of, largely qualitative, data … offering insights into the nature of the phenomena"* (Easton, 2010, p. 118).

The selection of cases was guided by the principle of purposeful sampling (Eisenhardt, 1989; Lenka *et al.*, 2018), because this research aimed at gaining an in-depth understanding of a complex emerging phenomenon through a limited number of organisations for theorising purposes rather than for representativeness in terms of population (Yin, 2009). The main criteria for the selection of the cases included: 1) the case organisations were selected from

western, developed countries due to the high maturity of PSS and ecosystem development in the west; 2) firms that were considered as large multinational corporations (MNCs) in the manufacturing and service industries; 3) firms that positioned themselves as leaders in PSS business ecosystems in their respective industries; and 4) firms that were willing to provide access for this research. From these criteria, two case organisations were selected from the co-authors' established connections. One is an engine manufacturer moving into smart port ecosystems via a servitisation strategy, and one is a logistics service company transforming to be a smart logistics manufacturing company using a productisation strategy. The two case organisations are summarised in Table 2.

Table 2 The profile of the two case organisations

Case No.	Core products/services	Approach	PSS business ecosystems
Case 1	Engines	Servitisation (e.g., repair, overhaul, electrification, condition-based monitoring, port scheduling, decarbonisation, environmental compliance, etc.)	Smart Port
Case 2	Transport and logistics services	Productisation (e.g., 3D printing, inspection, assembly, test, configuration, repair, return, etc.; Case 2 also invested in warehouse automation, alternative fuels and consultative services on decarbonisation and dematerialisation for a broader ecosystem offering)	Smart Logistics Manufacturing

As we aimed to explore the phenomenon from an ecosystem perspective, we also included views of the case organisations' suppliers, customers, and other (complementary) partners. The selection of these actors was based on emerging data during interviews. The unit of analysis in this research was the lead integrator in PSS business ecosystems. The case studies were conducted during 2017-2021, mainly through semi-structured interviews supplemented by documentation. As the research was highly related to the business strategy and the operating model, it was decided that the main interviewees should be top management team members across the whole value chain. The conceptual framework constructed in Section 2.3 was also used to guide the selection of interviewees and touch upon main sources for technical

integrations (TI), commercial integrations (CI) and social integrations (SI). The list of interviewees is provided in Table 3.

Table 3 The list of interviewees

Interviewees		Case 1 (Servitisation)	TI/CI/SI*	Case 2 (Productisation)	TI/CI/SI*
Interviewees within the case company		• Vice president (VP)	TI/CI/SI	• Head of Logistics	TI/CI/SI
		• Sales director	CI	• Head of digital manufacturing	TI
		• Global sales development director	TI/CI		
		• Digital director	TI	• Key account manager	TI/CI/SI
		• Business control director	CI	• Solutions design director	TI
		• Sourcing director	TI/CI		
		• Manufacturing director	TI	• Training and development lead	SI
		• Engineering director	TI		
		• Head of branding	CI/SI	• Head of continuous improvement	TI/CI/SI
		• Head of marketing	CI/SI	• Corporate communications manager	SI
Interviewees in partner's organisations	Customer	• Head of marine operations	TI/CI/SI	• Head of transportation (Hi-tech customer)	TI/CI/SI
		• VP of fleet asset management	TI/CI	• Head of logistics (hi-tech customer)	TI/CI/SI
	Vertical supplier	• Key account director	TI/CI/SI	• Head of supply chain (3D Printing company)	TI/CI/SI
	Horizontal partners	• Sales director (fuel supply systems)	TI/CI/SI	• CFO (3D Printing company)	CI/SI
		• Head of operations (Port 1)	TI/CI/SI	• Chair of independent research group	TI/CI/SI

* *Main data sources for technical integrations (TI), commercial integrations (CI) and social integrations (SI)*

A total of 27 interviews were conducted, with an average of one hour for each interview. NVivo 11 was used to build the database and manage the data analysis. Interview transcripts and other supplementary documents, such as reports and white papers, were imported into NVivo for coding because it helps researchers identify common themes (Miles *et al.*, 2013). As themes emerged deductively from literature and inductively from data, a start list of codes was created from the literature review. The coding framework evolved as new themes emerged from data analysis. A three-step coding method (Lenka *et al.*, 2018; Li *et al.*, 2022) was applied, where emerging data was labelled and grouped into sub-categories, categories, and theme codes. For example, from the literature, a starting list of codes such as vertical integration and horizontal integration were listed in the sub-category, then they were grouped into the category of 'technical' integration. During data analysis, the common words and phrases that the interviewees used, such as B2A, B2P and experience-based integration were labelled as sub-category codes, and then they were further linked to the category of 'social' integration, as shown in Table 4.

Table 4 An example of the coding process

Item	Codes from Literature	Codes emerging from data
Sub-category	Vertical integration, horizontal integration, outcome-based contract	B2A, B2P, experience-based integration
Category	'Technical' integration, 'commercial' integration	'Social' integration
Theme	PSS ecosystem integration	PSS ecosystem integration

4 Findings

The results of our investigation are structured based on the conceptual framework developed from the literature (Fig. 2 in Section 2.3) and seek to address our core research question, provided in Section 1 but repeated here for convenience:

How do organisations, whether through a servitisation or productisation approach, manage the development and integration of a PSS ecosystem from technical, commercial and social perspectives and considering B2B, B2P and B2A stakeholders?

At a high level, we found that both the manufacturing organisation (Case 1) and the service organisation (Case 2) pursued a similar three-step approach to developing a PSS business ecosystem. First, they sought to perfect their core products or services. Second, they added adjacent products and/or services that are next to the core. Third, they sought to integrate the peripheral products and/or services that sit at the surrounding of adjacent products/services. For example, Case 1 started with enhancing the performance of its core products (i.e., ship engines), aiming for high fuel efficiency and low emission that supported decarbonisation through engine electrification, digitalisation and alternative fuel development. This is illustrated by the quote:

To build the ecosystem, you should first develop the competitive knowledge from your core products and then integrate other adjacent products and services on top of it. Otherwise, third-party providers can also do it easily. – Global Sales Development Director, Case 1

Case 2 also enhanced its core transportation and logistics services by improving logistics planning, capability development, and transport routing to achieve the fundamental performance of on-time delivery and right first time. This is illustrated by the quote:

Before investing time in developing new products and services, we need to first get the fundamentals right in our core business. – Solutions Design Director, Case 2

Case 1 then added adjacent products such as propulsion systems, fuel supply systems, engine exhaust gas cleaning systems and related services through acquisitions and exclusive agreements. Case 2 introduced Logistics Manufacturing, where the company combined classic logistics services with more manufacturing activities such as sourcing, assembly, configuration, and product testing. It also developed adjacent products by investing in additive manufacturing (3D printing) because it foresaw that production had moved away from centralised manufacturing to a more distributed, close-to-end-user model.

For the third step, the integration of the peripheral products and/or services into a PSS ecosystem, Case 1 identified that many ports began to introduce strict environmental regulations (e.g., on engine emission and noise) and call for innovative solutions to achieve their ambitious decarbonisation targets. Case 1 saw the opportunities of developing a smart port ecosystem by integrating peripheral fleet and port management solutions such as ship route planning and port scheduling. Case 2 integrated peripheral services through partnerships. For example, it joined forces with a technical repair company to allow Case 2 to repair and remanufacture products closer to the point of demand, reducing the need to ship used products back to central repair centres and consequently reducing costs and CO2 emissions from excessive transportation. This included attempts at 3D printing of parts at the repair centres. The development paths of Case 1 and 2 are summarised in Table 5.

Table 5 The development paths of PSS business ecosystems

Case No.	Core products	Adjacent products/services	Periphery products/services	PSS business Ecosystems
Case 1	Ship Engines	Propulsion systems, fuel supply systems, exhaust gas cleaning systems and related services; digital tools	Fleet/port management solutions (route planning, port scheduling, navigation, weather forecast, environmental compliance services, etc.)	Smart Port
Case 2	Transportation and logistics services	Parts inspection, assembly, test, configuration, repair, and return. 3D printing; digital tools	Repair and remanufacturing of products close to the point of demand; consultative services on decarbonisation and dematerialisation	Smart Logistics Manufacturing

Our findings also indicated that along the 3-step development path, both Case 1 and Case 2 developed PSS ecosystem integrations from technical, commercial, and social perspectives. The details are provided in the following sections.

4.1 Technical, commercial, and social integrations in PSS ecosystems

4.1.1 Technical integrations in PSS ecosystems

Technical integration means developing and integrating new products, services, and digital infrastructure in terms of designing, engineering, structure, and process. For example, Case 1 developed condition-based monitoring as a digital service offering to detect engine anomalies remotely. As Case 1 moved into the performance-based model, it first remapped and rearranged the delivery processes by integrating its own services, including spare parts delivery, field service visits, engine upgrade, and condition-based monitoring. Then the integration went upstream and downstream in the vertical dimension as well as the horizontal dimension. For example, Case 1 integrated standard services of fuel supply and turbochargers that used to be provided by its upstream suppliers. Case 1 also took over customers' activities, such as routine maintenance and overhaul. Case 1 chose in-house development during technical integrations, mainly supplemented by partnerships. For example, Case 1 considered condition-based monitoring crucial to its core products and business model and should be embedded in its engines, so Case 1 chose in-house development. Case 1 also established several technical partnerships with shipyards, ship owners, ports, and digital start-ups to develop complementary products and services that could be integrated into its port ecosystem offering. Examples of these initiatives are illustrated in the quotes below:

Because the application is developed in-house, it is easy to bring it to our customers and possible to scale and integrate it into all our engine installations. If it were from a third-party solution, it would limit the usability and integration. We have tried similar tools made by other companies in the past, but they did not show great results. – Digital Director, Case 1

We know how far the wear limits are. Third parties can come and put sensors on, collect the data and give you a report. But will they accurately know what you will do with it? – Global Sales Development Director, Case 1

As a service company, Case 2 had close access to customers but did not have the technical product knowledge needed to develop a PSS. Case 2 indicated that the best way to develop its system offerings was by collaborating with others and engaging in partnerships. Consequently, Case 2 established a strategic partnership with a leading 3D printing company to experiment in manufacturing due to Case 2's initial lack of technical capabilities. As the 3D printing company did not have close ties to customers in the transportation and logistics industry, this partnership also allowed the 3D printing company to expand its markets. In addition, the partnership with the 3D printing company enabled Case 2 to offer repair services

for products returned to the warehouse. The partnership sought to bring both a commercial benefit and an overall environmental benefit. Together, the companies could offer their customers an integrated PSS offering: the possibility of repairing products to extend product life cycles closer to customers (the 3D printing company bringing the technical manufacturing capabilities and the Case 2 service company providing access and proximity to customers).

Case 2 developed carbon emission reduction services for customers through technical partnerships, which were considered must-have integrated services because of customers' committed environmental targets. Case 2 also partnered with several organisations across different industries, including wind electricity producers, hydrogen producers, hydrogen storage and distribution suppliers, and other stakeholders, including public utilities, governmental funding body and hydrogen industry network organisations, to develop decarbonisation capabilities. The technical integrations from Case 2 are illustrated with the quotes below.

We have the global footprint to distribute and locate the 3D printing equipment worldwide, but we do not yet have the technical capabilities to set up and run 3D printing operations. This is why we sought a partner to help us develop their capability and knowledge. – Head of Digital Manufacturing, Case 2

Environmental sustainability is not just about reducing CO2 from transportation; it is about dematerialising the full end-to-end supply chain, and to do that, we need to understand the product and its entire life cycle, not just the transportation steps. – Head of Logistics, Case 2.

The following section provides details of the findings related to the commercial integrations for PSS ecosystems.

4.1.2 Commercial integrations in PSS ecosystems

Commercial integration means integrating PSS offerings from a commercial perspective, such as defining terms and conditions, aligning financial incentives and accessing/controlling marketing channels. To illustrate this, Case 1 developed a performance-based model for which Case 1 and customers share risks and benefits. For example, it guaranteed engine performance, such as uptime and fuel efficiency, and customers paid based on engine running hours. If Case 1 failed to achieve the guaranteed performance, they had to compensate customers for the loss, while if Case 1 managed to achieve the agreed performance, such as fuel saving, they shared the benefits with customers. As a result, they had aligned incentives to work together on

improving engine performance and integrating more relevant products or services, either of their own or from other providers. The aligned incentives are illustrated with the quotes below:

The old relationship is based on 'We break, you fix, and we pay'. The engine makers really have no interest in ensuring their equipment on board is in perfect operation. With the guaranteed performance agreement, Case 1 took over many service activities from us, or other service providers… This long-term, mutual-beneficial deal incentivise both parties to make the engine efficient together – Vice president of fleet asset management, customer of Case 1

Case 2 sought to develop an OBC-type contract, which incentivised both companies to reduce costs and share any gains. Ultimately, the OBC-type contract was not fully approved and implemented, as in many cases, the balance of risk and reward between the two partners was not equal. For example, Case 2 proposed to carry out a study to help their customer reduce inventory costs by Case 2 company providing new manufacturing services. Case 2 proposed to do the study for free, on the condition that if savings could be identified from the proposed new set-up, both organisations would commit to sharing the realised benefits. The solution was not accepted but demonstrated Case 2 company's intent and aim to develop OBC-type contracts.

Commercial integration also happens when an organisation already has related products/services to the PSS ecosystem but does not yet have close ties to downstream customers or end users (often in new markets or an extension from B2B to B2C). For example, engines produced by Case 1 were also sold to land-based power companies. As power companies are often managed (directly or indirectly) by local governments, Case 1 does not always have direct ties to these downstream customers. Consequently, Case 1 first develops commercial partnerships with other energy providers in specific countries. Our investigation also found that Case 1 sought to acquire companies owning related products/services to the PSS ecosystem integration and close ties to downstream customers. By doing so, Case 1 could immediately gain access to the products, services, and customer intimacy. For example, Case 1 acquired a company specialising in optimisation of ship routes and port operations. The acquisition also allowed Case 1 to accelerate its development of social integrations (e.g., on decarbonisation and environmental compliance, to be discussed in the next subsection) and move closer to its vision of a Smart Port Ecosystem.

Similarly, Case 2 initiated commercial development to access and control marketing channels through partnerships. For example, Case 2 partnered with e-commerce development companies that gave them access to software to enable easier integration with local parcel and courier delivery companies to reach end-consumers and extend operations from B2B to B2C

deliveries. This allowed Case 2 to offer the front-end e-commerce platform in addition to its existing logistics fulfilment services. Case 2 also sought to acquire or develop a joint venture with a small digital start-up company that would have allowed the Case 2 company to access new, smaller customers and also provide faster, more flexible logistics services. Ultimately, the attempt at acquisition and a joint venture did not succeed due to unaligned incentives. Still, the example demonstrates that the interest in acquiring or partnering with a digital start-up existed.

4.1.3 Social integrations in PSS ecosystems

In addition to technical and commercial integrations, our findings also show that both Case 1 and Case 2 paid close attention to social integrations. Social integration means developing PSS ecosystem integrations by embracing other emerging social actors, particularly the B2A and B2P stakeholders, and shifting to (environmental) performance-oriented integration and/or experience-oriented integration.

B2A integrations

For Case 1, governmental and administrative authorities played an increasingly important role in drafting, approving, and governing marine/port ecosystem standards, platforms, and the new way of working. For instance, the European Council has released the EU's plan for a green transition 'fit for 55', for which new environmental regulations for marine transportation will be enhanced. Case 1 spent lots of effort enhancing its relations with the International Maritime Organisation (IMO), classification societies, port authorities, research institutes, and finance associations. The interactions can influence the process of drafting policies, standards and incentive programs that support new environmental regulations and decarbonisation in the marine industry. For example, classification societies can play a key role in the new ecosystem offering, such as Case 1's performance-based model and port management system, because they need to approve and/or govern environmental and safety compliance. The marine finance associations can decide whether and at which rate to lend money to ship owners or operators based on the (environmental) performance of the ship and key equipment such as engines. During these interactions, Case 1 also created opportunities to promote new offerings such as data-based predictive maintenance, the performance-based model and environmental compliance service for sustainable port ecosystem development. The focus on social integrations in Case 1 is illustrated in the below quote:

Ports should have one platform of communication where other different systems can plug in and share data from multiple platforms, so that we are efficient in the port ecosystem. For

example, vessels can be connected to ports and other maintenance service providers. We need smart digital platforms and decarbonised energy infrastructure, which requires close collaboration between government, the public and businesses. - Head of Operations, Port 1 (Case 1's partner)

Case 1 has strong social capabilities of dealing with many stakeholders in the marine industry and integrating products and services into the system offerings. We don't have this capability. Doing business with Case 1 is the easiest one for us because we don't have to discuss with so many stakeholders, including not only shipyards and ship owners, but class organisations, ports and design authorities – Sales Director, supplier of Case 1

Similarly, Case 2, with its commitment to global CO_2 reductions, engaged in partnerships with political and research institutions to share resources and ideas for developing sustainable solutions and shaping industry standards. For example, Case 2 joined an independent industry research group that sought to develop new industry standards and influence government policy in remanufacturing. The aim of joining the group was to access new information and knowledge to help the company develop new productisation offerings. In addition, Case 2 used their new knowledge about the customer and services needed to help influence and encourage policymakers to reduce the barriers to new companies repairing and remanufacturing products. This is illustrated in the below quote:

Many companies want to do the right thing by repairing and remanufacturing products to avoid them going to landfills, but in many cases, the government legislation around repairing and remanufacturing products is so complex that it becomes a barrier for companies to repair and remanufacture. - Chair of Independent Research Group (Case 2's partner)

B2P integrations

In addition to B2A integrations, B2P integrations also emerge with the increasing social awareness of environmental sustainability and decarbonisation targets. With the increasing impact of social media on the B2B decision-making process, Case 1 and Case 2 realised the importance of engaging with the public for its ecosystem integrations. For example, in Case 1, the functions of branding, marketing and sales joined forces to promote PSS ecosystem offerings through many channels, including public campaigns at ports, webinars with industry experts, academic communities, public figures and social influencers, talks with university students, and LinkedIn news and events. Case 1's customers can be ferry operators and container shipping companies, who are increasingly facing demands on more sustainable transportation from their end users (e.g., the public), especially in some European countries

and ports that have very strict environmental regulations and ambitious decarbonisation targets. The following quote illustrates Case 1's focus on B2P development:

Every customer contact is important: how we talk with customers and how do customers see our value is indeed connected to the public perception of our brand… When it comes to our customers' decision-making on engines and other marine equipment, the public's influence cannot be neglected. – Head of Branding, Case 1

For Case 2, it was also recognised that B2P integrations were important to demonstrate the company's commitment to environmental sustainability programmes and realise its vision in the ecosystem of Smart Logistics Manufacturing. Therefore, in addition to holding online interactive public events such as interviews and surveys through social media such as LinkedIn by sales, marketing and corporate communications teams, Case 2 also set up local partnership programmes. For example, Case 2 partnered with a UK university to disseminate their sustainability idea and indirectly raise customers' awareness about the sustainability initiatives that Case 2 company was working on. Case 2's focus on B2P development and its messaging to customers and the wider public is demonstrated in the following quote:

In the past, customers bought products because of quality, then as quality levels of different products became higher and higher, customer decision-making was more about cost. Now, the cost of many similar, high-quality products is about the same, so speed of delivery is often an order winner. In the future, we expect that the level of sustainability of the product and service will be the key differentiator in consumer decision-making. – Head of logistics, Case 2

Performance-oriented integration and/or experience-oriented integration

Our findings also indicate that partly influenced by social integrations, the two case organisations shifted to (environmental) performance-oriented integration and/or experience-oriented integration.

Performance-oriented integration means PSS ecosystem leaders integrate products or services to improve the overall performance of the broader ecosystem, not only from the financial performance perspective but environmental performance perspective. For example, Case 1 developed a performance-based model that guaranteed engine availability and fuel efficiency (financial performance) as part of the PSS ecosystem development path. With customers' setting their decarbonisation target to respond to governmental legislations and public pressures, Case 1 developed and integrated new offerings such as environmental compliance and decarbonisation services. To achieve financial and environmental performance,

Case 1 first integrated its services, including spare parts delivery, engine upgrade, and condition-based monitoring. Then the integration went upstream and downstream in the vertical and horizontal dimensions, such as partners that provided carbon-free or carbon-neutral products/services.

For a second example, Case 2 took several actions to make and optimise the performance-oriented integration. First, it established manufacturing hubs in various locations to source, assemble, configure, test, and deliver parts for high-tech industrial customers. Second, Case 2 integrated product lifecycle services, including remanufacturing, repairs and returns to improve its environmental performance. Case 2 also began to offer the service of calculating carbon emissions for customers and providing advisory services to customers on decarbonisation and dematerialisation. Many existing customers came to Case 2 and asked for help and support in analysing emission data, setting decarbonisation and dematerialisation targets, and providing decarbonisation and dematerialisation solutions. Case 2 committed to global decarbonisation and considered decarbonisation and dematerialisation a business opportunity. Consequently, Case 2 developed and integrated its existing digital services (mainly focused on CO_2 reductions in the logistics sector) with new manufacturing capabilities (productisation) and then additional service offerings (dematerialisation services).

Experience-oriented integration means that PSS ecosystem leaders add new physical products, service features and public infrastructure to enhance customer/end-user experience. For example, Case 1 continued developing and integrating new services, such as weather forecasts and optimised route planning for just-in-time arrival at ports. Case 1 also set up several co-creation experience hubs globally, where local communities, digital start-ups, academics, and the public can meet and co-create new solutions to improve the whole experience in PSS ecosystems. As a second example, Case 2 integrated the tracking APP for the emerging B2C segments so that end users can track the delivery status. Case 2 also sought to develop new methods of calculating the carbon impact of repairing products rather than allowing them to go to landfill or be recycled. This helped their customers better understand the trade-offs of transporting products back to a repair centre (by transporting products, CO_2 is produced) compared to the sustainability benefits of repairing products.

5 Discussion

The findings from this research provide new insights into developing PSS business ecosystems from both a servitisation approach and a productisation approach. Our research revealed preliminary yet meaningful guidance into holistic consideration of PSS ecosystem integration

from ‘technical’, ‘commercial’ and ‘social’ perspectives. The findings are generally aligned with the conceptual framework in Section 2.3.

Our research revealed that manufacturing and service organisations took a similar three-step approach to developing PSS business ecosystems: perfecting core products or services, adding adjacent products and/or services, and integrating the peripheral products and/or services into a PSS ecosystem. In general, in the first step of ‘perfecting the core’, organisations conducted technical integrations mainly, with some consideration of social integrations in designing more sustainable products/services. This is because integrations of new features to the core products/services naturally involves re-design and re-engineering (Matschewsky *et al.*, 2018; Morelli, 2002), and there is also a feedback loop requiring the design of PSS from a socio-technical systems perspective (Li, Rich, *et al.*, 2020; Liedtke *et al.*, 2015). In the second step of ‘adding the adjacent’, organisations conducted both technical and commercial integrations, and like step 1, with some consideration of social integrations. Finally, in the last step of ‘integrating the peripheral’, organisations conducted social integrations mainly, supplemented by commercial integrations. This finding adds new knowledge to literature. Details of the ‘technical’, ‘commercial’ and ‘social’ integrations will be discussed below.

First, regarding technical integrations, the findings indicated that manufacturing organisations with a servitisation approach are more likely to take over and integrate activities that their downstream customers previously did. This finding is in line with the phenomenon of ‘go downstream’ to control channels (Davies, 2004; Schmenner, 2009; Wise and Baumgartner, 1999) and the emerging value-based offering (Keränen *et al.*, 2021). Service organisations taking a productisation approach, however, focus more on developing upstream suppliers to integrate related physical products because (1) they have already controlled downstream relationships; and (2) they do not have their in-house production capabilities and need to tailor their system to a customer’s needs (Davies, 2004; Davies *et al.*, 2006). Horizontally, our research also confirms that integrations in PSS business ecosystems go well beyond the vertical dimension and embrace more horizontal complementary actors for adjacent and peripheral products/services, particularly to achieve environmental sustainability and decarbonisation targets. However, it remains a challenge for ecosystem leaders to determine which products/services should be considered adjacent or peripheral in the ecosystem integration to bring in expected financial benefits and avoid the so-called ‘servitisation paradox’ (Brax *et al.*, 2021; Gebauer *et al.*, 2005; Neely, 2008). This servitisation paradox requires manufacturers to move away from competing based on their products to competing based on their services. Yet, at the same time, delivery of these services relies on the production of high-

quality products. One can assume that a similar 'productisation paradox' may exist. Scholars also suggest that manufacturers tend to protect their technical know-how (Kianto *et al.*, 2010; Lenka *et al.*, 2018), and should keep the development of advanced services that are crucial to smart connected products in-house (Bustinza *et al.*, 2019; Porter and Heppelmann, 2014), which is in line with our findings in Case 1 (e.g. the condition-based monitoring). By contrast, service companies such as Case 2 are more open to partnerships for technical integration mostly because they centre on people, relationship and co-creation (Lenka *et al.*, 2018; Levitt, 1983).

Second, regarding commercial integrations, acquisitions (e.g., in Case 1) and strategic partnerships (e.g., in Case 2) provide a faster route to integrate related products and/or services and gain channel control. This finding is in line with our conceptual framework. It is recommended that ecosystem leaders should shift from a vertical hierarchy to a partnership (Tronvoll *et al.*, 2020). Our findings also indicate that partnership is increasingly becoming a topmost strategy, particularly for digital integrations. As Akio Toyoda, president of Toyota Motor Corporation, highlights, the new digital era is about 'making friends', namely building partnerships (Toyota, 2019). For example, Toyota established the CASE (Connected, Autonomous, Shared, and Electric) partnership with Isuzu and Hino, a new collaboration with NTT, and a new joint venture with Panasonic. As actors aim to find mutually supportive roles and develop coevolving capabilities in ecosystems (Moore, 1996), partnership in PSS ecosystems is dynamic and co-creative, which even challenges PSS ecosystem leaders. The findings from Section 4.1.2 show that both case companies sought to pursue similar commercial strategies on the performance/output-based contracts. It is interesting to note that Case 1 largely succeeded in integrating the PSS ecosystem, whereas Case 2 did not. Such a finding contradicts the conceptual framework and raises the question of whether PSS ecosystem integration is more difficult for service companies than manufacturing companies.

Third, regarding social integrations, the findings show that in addition to traditional B2B integrations, both manufacturing and service organisations consider B2A and B2P integrations. Our research extends the literature that investigates PSS integrations mainly from 'technical' and 'commercial' perspectives and provides a new angle of considering integration from a 'social' perspective. For B2A integrations, we answered the call of Burström *et al*. (2021) that B2A relations should receive more attention from academia. In connection to the failure of developing OBC in Case 2, clearly, it is the situation in which environmental or social benefits are strong but commercial incentives are weak, and policy intervention might work to create competitive conditions for the new solutions to stand a fair chance (Plepys *et al.*, 2015). For B2P integrations, it is mainly from the emerging public awareness on environmental

sustainability and decarbonisation and the shift to experience-centred thinking in PSS ecosystems. Our research sheds new light on understanding the differences between B2C and B2P, although they may be interwoven (e.g., in Case 2). Our research also echoes the literature that joint, synergised use of social media by branding, marketing and salespeople can largely impact the B2B decision-making (Cartwright and Davies, 2022; Kumar and Sharma, 2022; Salo, 2017).

The findings may also suggest that service organisations that take a 'productisation' approach in the B2C context can develop experience-oriented integration first and then move to performance-oriented integration. Whilst manufacturing organisations with a 'servitisation' approach are more likely to start with their physical products for performance-oriented integration and then expand to experience-oriented integration. Finally, integrations in PSS ecosystems are not simply bundling products and services from a technical perspective but emphasise the harmony and convergence of social and technical elements (Li, Kumar, *et al.*, 2020; Liedtke *et al.*, 2015; Morelli, 2002).

The comparisons between the two cases' PSS ecosystem development are summarised in Table 6.

Table 6 The comparisons between PSS ecosystem development

Item		Case 1 (servitisation)	Case 2 (productisation)
Development path	Perfect the core	Mainly technical integrations, with some consideration of social integrations	
	Add the adjacent	Technical integrations and commercial integrations, with some consideration of social integrations	
	Integrate the peripheral	Mainly social integrations, supplemented by commercial integrations	
Direction of integrations		Vertically, more likely to take over and integrate activities that their customers previously do; horizontally, more integrations with complementary partners, particularly digital partners and partners with products/services on environmental sustainability and decarbonisation	Vertically, focus on developing upstream suppliers to integrate related physical products; horizontally, focus on strategic partners that can help reach (wider) end users
Technical integrations		Be conservative on technology: keep core products and advanced services in-house; set strategic partnerships or make acquisitions (for adjacent and peripheral services)	Be open to technology: set strategic partnerships (for physical products and digital services)
Commercial integrations		Acquisitions of companies having both related products/services and close ties to downstream customers; Mature PBL/OBC	Strategic partnerships and acquisitions; Immature PBL/OBC
Social integrations		B2B, B2A and B2P; More likely to start with physical products for performance-oriented integration and then expand to experience-oriented integration	B2B, B2A, B2P and B2C; In the B2C context: advised to develop experience-oriented integration first and then move to performance-oriented integration

6 Conclusion

Our research provides several managerial and theoretical implications.

First, integrations in PSS business ecosystems not only occur in the vertical dimension, including upstream suppliers and downstream customers but also embrace more horizontal partners for adjacent and peripheral products/services from the same or different industries. Integration in the horizontal dimension is becoming imperative considering the ongoing digitalisation and social awareness and pressure on environmental sustainability and decarbonisation. In the vertical dimension, manufacturing organisations that take a servitisation approach are more likely to go downstream to enhance channel control. In contrast, while enhancing downstream integrations, service organisations with a productisation approach tend to develop and integrate related physical products upstream.

Second, although extant PSS literature mainly focuses on PSS integrations from technical and commercial perspectives, this research demonstrates the importance of a social

perspective, particularly a company's ability to engage with B2A and B2P stakeholders. Our research also found that organisations from manufacturing or services may meet each other in an ecosystem, with two opposite yet complementary, mutually embracing forces. For example, Case 1 and Case 2 meet in the same transportation ecosystem, particularly in decarbonisation. Although most PSS research to date has focused on the opportunities for manufacturing firms, PSS development may lead to more manufacturing and service companies thinking and behaving like one another and, or they may also begin to more closely compete with each other (Vandermerwe and Rada, 1988).

Third, the findings in this research also indicate that a holistic theory perspective is required to explain and guide the development of PSS ecosystems; theories such as resource dependence theory (Pfeffer and Salancik, 1978), systems theory (Von Bertalanffy, 1968) and socio-technical systems (Li, Kumar, *et al.*, 2020; Liedtke *et al.*, 2015; Morelli, 2002) appear the most appropriate. Service organisations with a 'productisation' approach in the B2C context are advised to develop experience-oriented integration first and then move to performance-oriented integration. The consideration of integration from an experience perspective is imperative for service-based organisations because they have the advantage of established customer experience for integrating physical products (e.g., the business practices of Amazon and Google through smart homes and smart cities). Whilst manufacturing organisations with a 'servitisation' approach can start with their physical products for performance-oriented integration and then expand to experience-oriented integration. In some cases, performance and experience-oriented integrations can be interwoven with each other.

Our findings add new knowledge to the literature of PSS ecosystems by a comparative case study in one manufacturing company with a servitisation approach and the other in a services company with a productisation approach. Specifically, our findings enrich extant literature on PSS ecosystem integrations and add a 'social' perspective by considering the B2A and B2P stakeholders. The findings also provide business practitioners with preliminary yet meaningful insights into holistic consideration of PSS ecosystem integration from 'technical', 'commercial' and 'social' perspectives. The research contributes to interdisciplinary collaboration among business strategy, industrial marketing, social marketing, public policy and supply chain management, which answers the call for interdisciplinary collaboration in B2B marketing (Lindgreen *et al.*, 2020; Markovic *et al.*, 2021).

Like many other studies, our research is not without limitations: (1) we conducted only two in-depth case studies in the transportation industry, which may limit the power of

generalising the findings; (2) we adopted a qualitative approach, and a quantitative approach to studying and measuring ecosystem success will add further evidence to the conclusions; (3) as the primary purpose of this paper was to conduct a preliminary exploration of the emerging phenomenon, we did not investigate some details such as how technical, commercial and social integrations interacted and evolved; and (4) although complementarity is a key factor for determining which products or services to be integrated into the ecosystem, our research does not explore how ecosystem leaders technically measure and determine the level of complementarity of adjacent or peripheral products and services. Consequently, the findings and limitations direct several future research areas.

First, it is strongly recommended to conduct more comparative case studies in manufacturing and service organisations to increase the power of generalisation. For example, more comparative case studies can help answer whether PSS ecosystem integration is more difficult for service companies than manufacturing companies, as indicated by this research. They can also help understand if there are differences for service organisations with a productisation strategy between B2B (e.g., Case 2's logistics manufacturing in this research) and B2C (e.g., Google's Nest devices and Amazon's Echo & Ring devices) settings. Consequently, comparative studies on the success or failure of becoming PSS ecosystem leaders are recommended so that practitioners and academia can learn from the failures (Jacobides *et al.*, 2018) and build on the successes. Comparative studies can also be directed to reveal more insights into performance-oriented integration and experience-oriented integration. For example, future research is recommended to explore if performance-oriented integration is more suitable for industrial B2B settings and experience-oriented integration favors more B2C settings with a productisation strategy where PSS ecosystem leaders add physical products based on already established good customer experience, as business cases of Google, Microsoft, and Amazon indicate. Even in the same case organisation, it will be interesting to investigate the co-evolvement and interactions between performance-oriented integration and experience-oriented integration. In addition, the selection of case companies should also cover several different industries. Second, quantitative research on measuring the success of technical, commercial, and social integrations is highly encouraged. Third, it will be interesting to see how manufacturing and service organisations holistically manage technical, commercial, and social integrations and their interactions to achieve a harmonised PSS ecosystem integration, for example, through the theoretical lens of socio-technical systems. Specifically, future research can be directed to two interlinked sub-areas: one area in studying how emerging digital technologies such as big data and artificial intelligence can enable smart

social integrations with authorities and the public on the right topic at the right time; and the other area in exploring better how the results coming from social integrations (e.g., through the B2A and B2P interactions) can influence technical and commercial development and integrations. For example, social integrations in Case 1 in this research align incentives on decarbonisation with port authorities, residents and local research institutes, start-ups and complementary partners. Technically, the latter are incentivised to design new products and services that can be integrated into Case 1's PSS ecosystem. Commercially, they can also apply for funds from a local environmental scheme resulting from the social integrations (e.g., thanks to the support from city council members and local residents). Such research will enhance the validation and revision of the conceptual framework constructed in Section 2. Finally, exploration in the complementarity assessment of adjacent or peripheral products and services for ecosystem integration is also recommended, so that ecosystem leaders can achieve expected financial benefits and avoid the 'servitisation paradox', or a similar 'productisation paradox'.

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