Reconciling and Reconceptualising Servitization Research: Drawing on Modularity, Platforms, Ecosystems, Risk and Governance to Develop Mid-Range Theory

Abstract

Purpose: This research bridges disparate research on servitization, namely Product-Service Systems (PSS) and Integrated Solutions (IS), to provide valuable insights for the progression of the field. It acts as a reconciliation of these research streams and offers a reconceptualised agenda incorporating recent research on platforms, ecosystems, modularity, risk and governance as key conceptual themes to synthesise and build theory.

Design: This is a conceptual, theory development article focused on advancing thinking on servitization by identifying systematic and theoretically informed research themes. It also proposes future research opportunities to advance theoretical contributions and practical implications for servitization research.

Findings: By reviewing and synthesising extant PSS and IS research, this article identified five core themes – namely modularity, platforms, ecosystems, risks and governance. The importance of these five themes and their linkages to PSS and IS are examined and a theoretical framework with a future research agenda to advance servitization is proposed.

Originality: This paper considers the similarities and differences between PSS and IS in order to develop theory and to reconcile formerly disparate research efforts by establishing linkages between core themes and identifying valuable synergies for scholars. The importance of the core themes, and current gaps within and across these themes are shown, and a mid-range theory for servitization is positioned to bridge the servitization-related PSS and IS communities.

Paper type: Conceptual paper

Keywords: *Servitization, modularity, platforms, ecosystems, governance, risk*

1. Introduction

Product service systems (PSS) and integrated solutions (IS) have provided significant advances in our understanding of servitization (e.g., Davies, 2004; Baines, et al., 2017; Rajala, et al., 2019). Defined as an integrated product and service offering that delivers value in use, the PSS research argues that servitization applies to all firms and industries (Baines, et al., 2007; Johnstone et al., 2009; Spring and Araujo, 2009; Raddats, et al., 2016; Baines, et al., 2017). It assumes that a wide range of manufacturers of consumer and capital goods are moving downstream by adding services to core product offerings. An often-cited example is Xerox's document management offering where the customer pays for the number of pages printed and all the repair and maintenance activities are carried out by Xerox.

IS research, by contrast, focuses specifically on high-value capital goods – known as complex products and systems – produced as one-offs or in small tailored batches to address the needs of large business or government customers (Hobday, 1998; Davies, 2004; Windahl, et al., 2004; Davies and Hobday, 2005; Windahl and Lakemond, 2006; Rajala et al., 2018). It argues that firms are focusing on becoming systems integrators by offering products and services as integrated solutions to specific customer requirements such as IBM's 'outsourcing solutions', Alstom's 'Total Traincare Solutions' or Kone's 'best people flow experience' (Davies and Brady, 2000; Davies, et al., 2001; Davies, et al., 2003; Davies, 2004; Rajala, et al., 2019).

There are distinct parallels between the two research communities. PSS is a broad description of the trend towards servitization and often refers to IS research (Johnstone, et al., 2009; Baines, et al., 2017) and well-known examples, such as Rolls-Royce's shift from selling jet engines to 'Power by the Hour'. Improvements in performance in both PSS and IS are achieved by standardising product modules and service components, although IS remain highly customised to address individual requirements (Roehrich and Caldwell, 2012). However, there are also critical distinctions between PSS and IS that lead to differences in how they are designed and delivered. This is worthy of a detailed and systematic investigation and comparison as offered in this paper. Despite the significant advances in our understanding of servitization provided by prior PSS and IS studies (e.g. Cusumano, et al., 2015), there has been little reconciliation of PSS and IS research streams as both have largely developed in parallel. This is puzzling given the similarities and overlaps in the phenomena that both the PSS and IS research streams examine. Our understanding of servitization can be advanced and reconceptualised by incorporating and synthesising recent thinking about platforms and ecosystems (cf. Kohtamäki, et al., 2019) and ongoing debates about modularity (Rajala, et al., 2018), risk and inter-organisational governance (cf. Bastl, et al., 2019).

Platforms are becoming increasingly important to firms (Gawer and Cusumano, 2014) and those implementing servitization (Cenamor, et al., 2017; Kohtamäki, et al., 2019). Platforms can be either internal or external to a firm and are arrangements of assets that allow complementary products or services to be developed (Gawer and Cusumano, 2014). The deployment of platforms is often associated with ecosystems where 'actors organize around a platform' (Jacobides, et al., 2018, p.2257). Ecosystems connect firms with disparate capabilities which some firms use to digitally servitize (Kohtamäki, et al., 2019; Skyler, et al., 2019).

Key to the emergence of ecosystems is modularity, specifically technological (or process) modularity (Jacobides, et al., 2018). For example, in addition to process modularity, product modularity has long been known to be important to manufacturers in order to achieve economies of scale (Ulrich, 1995). Modularity is vital to firms wishing to servitize as it enhances efficiencies (Rajala, et al., 2019) and improves collaboration between interdependent firms delivering complex systems (Tee, et al., 2019). In addition to understanding the various structural arrangements of firms in ecosystems it is important to identify how ecosystems function. Cooperation between firms in an ecosystem is vital for a firm to access the resources of another (Hannah and Eisenhardt, 2018). Control and coordination are also appropriate governance mechanisms for firms that are seeking to servitize (Bastl, et al. 2019; Roehrich et al., 2020). A further consideration for firms that are seeking to servitize is the role of risk (Neely, 2008). Many studies are inconclusive as to whether the adoption of servitization leads to greater (Gebauer, et al., 2005) or lesser (Benedittini, et al., 2017) risks. However, risk can be mitigated by increasing coordination efforts between firms (Bastl et al., 2019).

There is value in theorising concerning the linkages amongst platforms, ecosystems, modularity, governance (i.e., control and coordination) and risk. These have been investigated independently but not holistically, despite the clear interdependence of these themes. For example, while the firm is the primary unit of analysis informing servitization research (Rabetino, et al., 2018), research has also started to explore the role of ecosystems in the design and delivery of PSS (Kohtamäki, et al., 2019) and IS (Davies, et al., 2007). Yet it is unclear how platforms for servitization are delivered through ecosystems (cf. Gawer and Cusumano, 2013). The concept of ecosystems addresses how the governance of the inter-organisational relationships in the ecosystems is arranged and performed to manage risks and coordinate tasks and activities. This has, generally, been posited as a fruitful area for research, especially around platforms and ecosystems (cf. Jacobides, et al. 2018), but it does not directly examine IS and PSS. There is little extant research that explains how the governance (i.e. coordination and control) of the supply chain (or ecosystem) works in practice (cf. Bastl, et al. 2019; Roehrich, et al., 2020). Instead, much of the literature has

focused on what governance mechanisms are (cf. Sjödin, et al., 2019), with only limited research on how risks are managed, and tasks are coordinated.

The purpose of this study is to draw upon research from the servitization field, including the foundational works, and adjacent fields – comprising modularity, platforms, ecosystems, risks and inter-organisational governance – to advance mid-range theory. A mid-range theory 'falls between the "minor working hypotheses" of everyday life and "all-inclusive" grand theories' (Glaser and Strauss, 2008, p.33) It is a 'context-specific conceptualisation providing theoretically grounded insights readily applicable to an empirical context' (Craighead, et al., 2016, p.241). It helps to develop new theory and reformulate existing conceptual work applicable to servitization, rather than other contexts. In order to build a mid-range theory, we review, critique and synthesise the conceptual similarities and differences between PSS and IS as well as identify gaps and complementary lines of inquiry in recent literature to guide new research into servitization. Hence, rather than seek to provide a systematic literature review (see, for example, Lightfoot, et al., 2013; Rabetino, et al., 2018; and Raddats, et al., 2019, for reviews), this research develops theoretical propositions and potential future research avenues to be explored. Drawing out the connections between PSS and IS, and building on adjacent research streams in strategy and operations management literature is a timely and vital effort for servitization research to progress towards a more coherent, systematic and theoretically informed research agenda.

2. Theoretical background and the growth of servitization

The following sections take stock of research investigating products, services and integration in offering PSS and IS, before exploring the implications for research on servitization.

2.1 Products, services and solutions

The growing trend for firms to provide services with products (e.g. Baines, et al., 2007) has been described by Vandemerwe and Rada (1988) as offering customer-focused packages (or 'bundles') of goods, services and knowledge to add value to core offerings and provide solutions to address a client's needs. In contrast to tangible physical products, services are knowledge-based, intangible and are consumed during production (Spring and Araujo, 2009). Cusumano et al. (2014) distinguish between services that complement a core product offering (product smoothing and adapting) and services that substitute for the purchase of a product (providing customers with the opportunity to pay for the usage rather than the purchase of the product).

Organisations following a servitization strategy seek to: (i) increase customer demand and lock-in relationships; (ii) realise further growth, increased profits and stability; and (iii) rationalise

scarce resources (Wise and Baumgartner, 1999; Raddats, et al., 2019). Similarly, firms (or networks of firms) that deliver IS (Hobday, et al., 2000) generate revenues from an installed base of products with a long life cycle (Potts, 1988). Offerings also include public sector infrastructure projects via build-operate-transfer (BOT) or design-build-finance-operation (DBFO) (Hartmann, et al., 2014; Roehrich, et al., 2014) offering products/infrastructure combined with services such as facilities management (Caldwell, et al., 2009). Improvements in performance and outcomes are achieved through arrangements such as integrated build and maintenance service solutions and whole life cycle costing (via bundling design, construction and operations phases) of deploying public assets (Brady, et al., 2005; Roehrich and Caldwell, 2012). Overall, Wise and Baumgartner (1999) suggested that manufacturers need to 'go downstream towards the customer' (p.133). This motivation is based on revenue generation, especially for firms with large installed product bases (Windahl, et al., 2004). Prior work investigates methods for the delivery of services together with some of the potential barriers to success in transforming firms into product-service providers, such as incoherent strategy formulation and missing capabilities for firms (Martinez, et al., 2010; Sousa and da Silveira, 2017), incomplete organisational and business model changes (Bigdeli, et al., 2017) and increased product and services complexity (Neely, et al., 2011; Raddats, et al., 2016).

Solution clients are not simply concerned with the value obtained from the physical product, but 'look for solutions that serve their own value-generating processes' (Grönroos, 2000, p.4). Caterpillar, the world's largest construction equipment manufacturer, provides a useful example of a solutions strategy. It offers services via the 'Cat Product Link', a remote tracking and monitoring service, providing updates on the location of clients' equipment in real-time, and valuable information to deliver preventative maintenance monitoring of components, thus reducing downtime of vital construction equipment. In this way, clients buy a guaranteed solution for trouble-free operation (Davies, et al., 2006). The ability to continuously create customer value is a central theme in strategy, operations and marketing (Ulaga, 2001; Matthyssens and Vandenbempt, 2008). Thus, organisations servitizing their products and providers of IS (e.g., Wise and Baumgartner, 1999; Brax and Jonsson, 2009), aim to create a lasting competitive advantage for clients by addressing the challenges of life cycle management, including maintenance, increased product/solution reliability and inter-operability (Kowalkowski, et al., 2017). An important element of this phenomenon is a shift to services provided in combinations with products as PSS (Baines, et al., 2009; Baines, et al., 2017) or IS (Davies, 2004; Rajala, et al., 2019). The following sections take a closer look at PSS and IS as two archetypes of servitization to inform the development of core themes and advance servitization research and practice.

2.2 PSS and IS

While PSS research evolves from varying perspectives and disciplines such as engineering, management, design and environmental studies, there are a few common themes (Baines, et al., 2020). First, most manufacturing firms have discovered that their revenues are dominated by their service offerings compared to their manufactured products (Cook, et al., 2006; Rabetino, et al., 2018; Sjödin, et al., 2019). Second, firms' offerings are an integration of material (tangibles) and non-material (intangibles) components with the collective aim of fulfilling customer needs (Karatzas, et al., 2017). Third, PSS can change how firms produce and customers consume (Visnjic, et al., 2016). The underlying assumption is that the value of a product to the customer lies in the benefits they attain from the product rather than from product ownership, suggesting that the IS provider shifts focus from the means of achieving such benefits (the product) to the benefits themselves (Visnjic, et al., 2016).

Servitization is conceptualised as a Product-Service (P-S) transition from pure product to pure service offerings (Oliva and Kallenberg, 2003). Within this transition, there are various combinations of products and services forming three categories of PSS (Baines, et al., 2007; Baines, et al., 2009): (i) product-oriented services, where the ownership of the product is transferred to the customer and a service arrangement is put in place to utilize the product over its life cycle; (ii) use-oriented services, where ownership of the product is retained by the service provider to provide the function(s) for the product to the client (e.g., leasing a product for its use); and (iii) result-oriented services, where the service provider provides results or outcomes rather than merely functions. Here, the client or customer pays for the outcome instead of the function of the product which is often supported by performance-based contracts. Further research classifications such as the research by Brax and Visintin (2017) and Ulaga and Reinartz (2011) have built on this work. For instance, Brax and Visintin (2017) position three different approaches to represent servitization in prior studies: (i) end-state models; (ii) gradual transition models; and (iii) stepwise progression models. These approaches are characterised by increasing complexity of the offering and customer value, but also changes in operational responsibilities in the value constellations. Ulaga and Reinartz (2011) develop a comprehensive framework that integrates different key capabilities and resources needed for manufacturers when seeking to combine products and services successfully.

IS research emerged from studies of innovation management in high-value capital goods – or complex products and systems (Davies and Hobday, 2005) – and has more recently been grouped under the wider 'solutions business' research community (Rabineto, et al., 2018), including industrial marketing, engineering and services operations management (e.g., Neely, 2008; Martinez, et al., 2010). Systems integration – the ability to design and integrate components produced by internal

and external suppliers – is one of the core capabilities of IS suppliers (Davies, 2004; Naghizadeh, et al., 2017). For instance, the study by Paiola, et al. (2013) outlines a framework including four distinct strategic approaches relating to service components and the development of capabilities (either in-house or bought in). Prior research on IS showed that high revenues are derived from an installed base of products with a long life cycle, but services lead to higher and more stable profit margins than products (Anderson, et al., 1997; Rajala, et al., 2019). Industries supplying IS are usually bilateral oligopolies with a small number of large systems integrators facing a few large customers, or monopolists in each country (Hobday, 1998). Systems integrators have to 'know more than they make' in order to coordinate large networks of decentralised and self-directed organisations including component suppliers, manufacturers, services providers, financial institutions, government authorities and operators (Brusoni, et al., 2001; Hobday, et al., 2005). In other words, systems integrators require combinatorial capabilities to bring together diverse knowledge bases (Gruber, et al., 2013). Generally developed and delivered on a project basis as one-offs or in small tailored batches, IS depends on temporary structures (when compared to PSS) involving many firms and entailing far more significant network coordination issues than traditional serial transaction-based approaches. Thus, both PSS and IS are reliant upon networks and ecosystems to deliver and support them rather than linear, hierarchical supply chains.

In high-volume industries, a set of standardised services are traditionally provided after the product is delivered. In the 1990s and early 2000s, customers developed customised offerings for the co-creation of mass-produced goods (Lampel and Mintzberg, 1996) and personal experiences for consumers (Voss, 2003). In low-volume IS, by contrast, products and services are provided as IS through the life of the product – from early engagement through design to production and operations – to meet the needs of large business and government customers (Gann and Salter, 2000; Davies, 2004; Park, 2013; Majidpour, 2016). What most of these customised offerings have in common is the opportunity for establishing more strategic engagements with buyers/clients, emphasising the need for more long-term, collaborative relationships (Lewis and Roehrich, 2009), which are often supported by organisational restructuring. For example, Salonen and Jaakkola (2015) examine how lead manufacturers choose between an internal versus external resource integration approach as they transition to solution-based business and thus provide alternative approaches to organising solution provision. Similarly, prior studies show that firms moved downstream into services, developed new capabilities and changed their organisational assets in order to provide the range of services and products that customers need. For example, Galbraith (2002) argues that firms must restructure to create customer-centric organisations. Conversely, Wise and Baumgartner (1998) argue that firms move downstream from manufacturing into IS, while

Davies (2004) shows that firms based in services (systems integrators of externally supplied product components) can move upstream (integrate backwards) into IS. For example, engineering consulting firms like WS Atkins moved toward the provision of integrated solutions by adding products to its original service offerings.

Firms moving from manufacturing or services need to develop core capabilities in systems integration and operational services, and often additional capabilities in business consulting and financing (Davies, 2004; Davies, et al., 2006; Raja, et al., 2018). Since the 1990s, many large providers of corporate telecommunications offer to manage and integrate different suppliers' technologies and products with services as global outsourcing solutions. The transition is not without challenges and many early movers into IS experienced considerable difficulties in their efforts to create and capture high-value complex offerings (Davies, 2004; Baines, et al., 2009). They faced a choice between specialising in component supply or becoming 'integrators' of product and service components supplied by an expanding international supplier network. They also had to create new organisational forms based around projects and customer-centric structures for IS (Foote, et al., 2001; Galbraith, 2002; Davies, et al, 2006; Raja, et al., 2018). As firms like IBM and Ericsson discovered, the provision of IS depends on developing the capability and willingness to specify, design, integrate and support a competitor's hardware if that is what a customer requires (Davies, et al., 2006). Being a multi-vendor provider is, according to IBM, the 'acid test' of IS provision (Gerstner, 2001).

In summary, the current literature on servitization provides important insights into key issues of PSS and IS, but suffers from some limitations. Prior work on PSS is fragmented between several research areas such as strategy, operations, innovation, engineering and design and consequently develops thinking in parallel, with little integration. By contrast, the foundational work on IS was primarily confined to innovation management, although it drew upon insights from adjacent studies of services and has more recently developed into other parallel research areas. As studies of learning from related fields of research show (Davies, et al., 2018), a deeper effort is required to understand how seminal and recent developments in servitization can converge and how neighbouring research streams (such as modularity, platforms and ecosystems) can inform fruitful conceptual avenues for concerted future research, building on strong theoretical foundations.

This research develops mid-range theory for servitization by building on extant research and thus bridging the communities, looking for synergies and more coherent knowledge accumulation. In order to do so, five core themes are examined to advance the field's thinking. Themes I and II theorise the interplay between modularity and platforms, as both PSS and IS require products and

services that are modular and standardised (Baines and Lightfoot, 2014) building on a common architecture – a platform - to create the offering (Gawer and Cusumano, 2013). This synthesis is important to advance thinking on servitization and to draw out different types of platforms and the role of modularity of products and services in achieving PSS and IS. Theme III adds clarity to understand how platforms for servitization are delivered, and explores the crucial role of ecosystems (Gawer and Cusumano, 2013; Kohtamäki, et al., 2019). Then, themes IV and V synthesise prior research on how the various relationships between firms are governed in ecosystems both to manage risks through governance mechanisms and to coordinate tasks and activities (Roehrich, et al., 2020). These are important, yet underexplored, areas of research for servitization, as firms need to manage risks and coordinate tasks of ecosystem members.

3. Theory development for servitization

Theme I: Modularity of products, services, information and processes

As value continues to shift away from products to services (Cusumano, 2004; Cenamor, et al., 2017), firms face the challenge of building the services-side of their business by improving service innovation (den Hertog, et al., 2010; Kindström, et al., 2017) and developing modular service offerings. Modularity consists of 'building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole' (Baldwin and Clark, 1997, p. 84). By developing standardised and modular components that can be (re-)configured around a variety of customer needs, suppliers can combine the scale advantages of producing lower cost standardised components with high flexibility and scope in system design (Mattson, 1973; Rajala, et al., 2018). Innovation then stems from the combination and re-combination of pre-defined subsystems or modules (Crespin-Mazet, et al., 2019). With a few early exceptions (e.g. Davies et al., 2006), the concept of modularisation has attracted limited attention in servitization research (Brax, et al., 2017; Rajala, et al., 2018). In a modular system, standardised interfaces (defined as a standard conform point of interconnection) and interchangeable components can be upgraded and adjusted with less dependence on managerial coordination (Rajala, et al., 2018).

Innovation for servitization providers, as with manufactured products, is improved by the creation of standardised interfaces and modular components (e.g. Sanchez and Mahoney, 1996; Baldwin and Clark, 2000). Modularity enables many suppliers to design and produce components of a product and/or service as long as they conform to a predetermined design. The trend towards modularity has increased the possibilities for firms to specialise in component supply or systems integration, although it is recognised that firms can gain higher value-added at the systems level (Rajala, et al., 2019). Other studies have cautioned that the spread of modularity may often be

limited to some complex product industries, comprising tightly-coupled components and proprietary interfaces, such as aero-engines (e.g. Brusoni, et al., 2001).

Although product innovation can be improved through modularity and standardised interfaces, less is known about how firms may turn services from ad hoc, one-off assignments into repeatable and scalable processes, and what specific managerial approaches are developed to package, simplify and reuse service offerings (cf. Helkkula, et al., 2018). Firms can only achieve long-term and profitable growth if standardised components can be reconfigured to provide customised solutions at the system level (Hannaford, 1976). Service modularity applies the same principle to services where a further principle, beyond re-configurability, is how the service module interfaces with other service modules (Brax, et al., 2017). This can lead to 'economies of scope' (efficiencies formed by variety, not volume, where the production of one good reduces the cost of producing another related good) for solutions providers. Within this context, the solution to a customer's needs is a customised adaptation of a modular system and its standardised components.

Prior research on IS recognised that service, as well as product components, can be standardised by recreating replicable modular components and combining them in different ways to address specific customer needs (Galbraith, 2002; Davies, et al., 2006). Early research showed that IS providers initially focus on providing highly customised solutions to a customer's problem, since this capability distinguishes a supplier from its competitors (Davies, 2004). However, creating a bespoke solution for each customer is expensive, and pioneering IS providers in the 1990s – such as IBM and Ericsson – soon recognised the advantages of offering customised solutions at lower cost, comprising a standardised portfolio of services (Davies, et al., 2007; Brax and Jonsson, 2009). By creating a portfolio of product-service modules firms needed to develop the systems integration capabilities required to offer them in different combinations (Davies, et al., 2007).

To achieve profits in IS provision, knowledge gained from initial offerings (which are often delivered via projects) must be shared and codified for reuse in subsequent projects. Performance is improved by replicating product and service components until they become standardised offerings, used repeatedly for many projects at lower costs. IS providers established portfolios of modular product and service components that could be combined to offer customers a range of standardised and customised solutions. In line with this, early research also showed that IS providers can gain 'economies of repetition' achieved by performing standardised, repeatable and reliable routines on each project and reusing such capabilities across a number of projects (Davies and Brady, 2000; Brady and Davies, 2004; Manning and Sydow, 2011; Rajala, et al., 2018). While early studies of IS addressed product and service modules offered by the firm, subsequent research on project networks experience also identified tensions between standard operating procedures (routines) and

customised, crafted solutions to the challenges of unexpected or innovative project work tasks and challenges (DeFillippi and Sydow, 2016).

Building on this early IS research, Kowalkowski, et al. (2015) argue that firms industrialise their offering by standardising and modularising previously customised solutions to promote repeatability and scalability. Modularity is characterised by the separability of tasks along a value chain (Jacobides, et al., 2018). In other words, the standardisation of product and service components is key for servitization providers to offer a range of products and services which are then combined to fit a client's needs. The combination of different services and new service development/design (e.g., Bitner, et al., 2008) including, for example, digital services (e.g. Kohtamäki, et al., 2019), help to drive service innovation for firms, and thus have the potential to generate more revenue.

As has been shown so far, servitization providers need to balance the need for standardisation (i.e. making something conform to a standard) and customisation (i.e. modifying something to suit a particular individual task, organisation or system) of their offerings by considering (product/service) modularity and service innovation. This is often supported by process and information modularity. Process modularity, like product modularity, is where the process comprises independently designed subsystems that can be reconfigured to function holistically (Vickery, et al., 2016). Cenamor et al. (2017) also posit that for PSS, information can be modular leading to information modularity through the connection of information systems. One example of this is the interconnection of maintenance systems and telematics for goods vehicles to facilitate servicing and aid in increasing efficiency (Karatzas, et al., 2017). Information modularity allows the standardisation of information and the connection of discrete systems of firms within the network in order to improve the efficacy of the support of PSS (Karatzas, et al., 2016).

While modularity has been applied to IS provision, there are limits to the standardisation of products and components of services. The trend towards IS was observed in industries where production is undertaken in low volumes and customers require novel solutions to their individual requirements. For example, telecommunications networks will have modularity around the product components within the network (e.g., base stations, terminals), the processes used to deploy and support them (i.e. how the network is configured), and the way in which the products within the network interact (i.e. information modularity). By contrast, modularity may be more significant in PSS where entirely standardised products and services are produced in high volumes. Scale and scope economies are difficult to realise in IS, as the volume is low while customisation is high. Based on these conclusions, it is postulated:

Proposition 1a: PSS and IS providers deploy modularity to increase economic efficiency.

Proposition 1b: While PSS mainly focuses on standardisation of product and service modules to achieve economies of scale and scope in high-volume production, IS requires more process modularity to achieve economies of repetition in low volume project-based production.

Modularity – product, service or process - is important in the delivery and support of PSS and IS. Platforms are a form of modularity (Kretschmer, et al., 2020), and these are examined in the following section.

Theme II: Platforms for servitization

While platforms appear to be a relatively recent phenomenon (Gawer and Cusumano, 2002; 2008; Cenneamo, 2016; Eloranta and Turunen, 2016), the term platform has long-standing use in manufacturing (cf. Henderson and Clark, 1990). Platforms are an extended form of modularity and a specific type of business model. They are sometimes referred to as meta-organisations, or 'organisations of organisations', that are less formal and less hierarchical structures than firms, and yet more closely coupled than traditional markets (Kretschmer, et al., 2020).

Platforms have spurred new products and services, sparked innovation and improved economic efficiency in various industries and technology sectors (Kretschmer, et al., 2020). Gawer (2014) argues that platforms can be usefully conceptualised as evolving organisations or meta-organisations that: (i) federate and coordinate constitutive agents who can innovate and compete; (ii) create value by generating and harnessing economies of scope in supply and / or in demand; and (iii) entail a modular technological architecture composed of a core and a periphery. Thomas, et al. (2014) conduct a systematic review of the platform literature and identify four distinct streams: (i) organisational platforms; (ii) product family platforms; (iii) market intermediary platforms; and (iv) platform ecosystems.

More recently, platforms have been treated as business models where the platform is a digital hub (e.g. Apple's App Store, Uber, AirBnB) that enables suppliers to connect and sell services to a wider audience (cf. Cenamor, et al., 2017; de Reuver, et al., 2018; Kohtamäki, et al., 2019). However, historically a platform has been used to refer to a re-usable component within the architecture of a wider product system. For example, VAG use the 'Modularer Querbaukasten' (MQB platform) on the Audi A3, VW Golf, Seat Leon and Skoda Octavia (Cameron and Crawley, 2014) to reduce costs while still offering the flexibility to be used in different vehicles. Some firms such as

Intel and Microsoft have successfully used modularity to achieve competitive success through 'platform leadership' (Gawer and Phillips, 2013). Similarly, AirBnB and Amazon allow producers, consumers and other organisations to connect and facilitate transactions with each other. With a particular focus on small- and medium-sized enterprises (SMEs), Kowalkowski, et al. (2013) present two roles of a platform in organising inter-firm value constellations in the servitization context. The first is an operative platform – a 'shared service platform' – that enables third parties (supply chain members) to provide services in addition to the offering of the focal firm. The second approach resembles an online marketplace in which the focal firm has a 'customer-to-customer intermediary' role, facilitating the independent transactions between the demand and supply side.

Product and more recently service development has been improved by developing standardised and repeatable processes based on modular components that form a platform – or system – of interdependent core and complementary products (Cenamor, et al., 2017). Firms have, however, experienced difficulties in obtaining similar improvements in services. Some firms are attempting to improve service productivity and innovation by emulating the replicable approaches traditionally found in product development. A key challenge facing firms moving into servitization (including PSS and IS) is to create modules that form core and complementary components of a platform – that can be combined and recombined on each platform to provide innovative solutions to meet customer needs. Although it is now well understood how modularity and platform strategies drive innovation in products, more research is required to understand how such managerial approaches can or should be applied to improve innovation in services.

Gawer and Cusumano (2014) propose that internal platforms (i.e. internal to the firm) are 'a set of assets organised in a common structure from which a firm can efficiently develop and produce a stream of derivative products' (p. 418). One example of an internal platform is the CFM56 range of engines manufactured and sold by CFM, a joint venture of General Electric (GE) and Safran. These modular engines power a range of aircraft and are used when GE provides engines as PSS (cf. Cohen et al., 2006). In this respect, PSS can be considered as internal platforms. While there are undoubtedly third parties involved in the delivery and support of the offering, these third parties often provide very standard products and services that have the potential for usage in other industries (cf. Bastl, et al., 2019).

One of the debates within research examining IS has been whether a firm should sell systems or integrate them, thus using industry or external platforms. Gawer and Cusumano (2014) defines external or industry platforms 'as products, services, or technologies developed by one or more firms, and which serve as foundations upon which a larger number of firms can build further complementary innovations and potentially generate network effects' (p.420). Davies, et al. (2007)

posit that firms were beginning to move away from being systems sellers to becoming systems integrators, as no one firm could provide everything. For example, the two most recent UK Navy aircraft carriers were built through the Aircraft Carrier Alliance, a consortium of the UK Ministry of Defence, BAE Systems, Thales, Babcock and VT Group with Thales acting as the systems integrator. The specificity of the products and services utilised in such an endeavor means that they have little utility in other applications. As such, IS are external platforms. It is therefore postulated that:

Proposition 2a: Both PSS and IS use platforms to innovate, increase economic efficiency, and provide offerings of standardised and customised components.

Proposition 2b: PSS mainly utilise internal platforms, while IS often requires external platforms in order to drive innovation in integrated products and services modules.

Platforms, whether internal or external, are critical to the delivery of PSS and IS. Platforms are often deployed in ecosystems (Jacobides, et al. 2018) and their linkages to PSS and IS are considered in the following section.

Theme III: Value-creating networks and ecosystems

Servitization is often delivered by more than one firm (Johnson and Mena, 2008) and much of the prior work on servitization examines inter-organisational considerations from the standpoint of dyads or supply chains (cf. Chakkol, et al., 2014; Kohtamäki, et al., 2020), rather than networks and ecosystems (cf. Kapoor, et al., 2021). However, the dyadic or supply chain perspective fails to capture the inherent complexity of roles and relationships in economic systems. Hence, a value network or ecosystem perspective may be adopted to understand the entire value-creating system. With the value network concept, value is co-created by a combination of actors in the network (Peppard and Rylander, 2006; Bustinza, et al., 2019; Möller et al., 2020). This value-creating system aims to reconfigure roles and relationships among the constellation of actors in order to mobilise the creation of value (Kohtamäki, et al., 2019), thus emphasising the interactive, less sequential value creation among various parties (Normann and Ramirez, 1993). Adopting a network approach, organisations should focus not only on the firm or the industry, but the value-creating system itself, within which different economic actors – supplier, partners and customers – work together to co-produce value (Kohtamäki, et al., 2019).

Servitization providers need to consider the structure of the network that delivers and supports the offering, as there are distinct changes (Martinez, et al., 2010; Bastl, et al., 2012;

Kowalkowski, et al., 2013). Because of the service component of the offering, linear, uni-dimensional supply chains become networks where third-party service providers interact directly with the customer, forming networks (Karatzas, et al., 2016; Bastl, et al., 2019). Thus, networks are key to organisations implementing servitization (Baines, et al., 2009). For example, Galbraith (2002) and Tuli, et al. (2007) stress the importance of relationship management especially when offerings move from being 'product-oriented' towards being 'result-oriented'. This is supported by Finne, et al. (2015) and Davies (2004, p.753) who argue that 'for many firms, the biggest challenge will be developing the capabilities to integrate different pieces of a system provided increasingly by an external network of specialized component suppliers, subcontractors and service providers.' Conversely, foundational research on IS largely focused on the firm (systems integrator) and its relationship with the customer (Davies, 2004).

An even wider perspective is offered by the concept of ecosystems which differs from supply chains in terms of their structure and the behaviours of the actors (Jacobides, et al., 2018). While supply chains tend towards vertical, hierarchical arrangements (or hierarchy-based value systems) where price and quality are fixed, networks and especially ecosystems are more horizontal than vertical and more independent than hierarchical systems (Jacobides, et al., 2018). Over the last few years, there has been a surge of interest in the concept of 'ecosystems' as a new way to depict industries' competitive environments (Adner, 2017; Bustinza, et al., 2019). Thus, a (business) ecosystem is characterised by a network of organisations and individuals that co-evolve their capabilities and roles and align their investments to create additional value and/or improve efficiency (Moore, 1993). An ecosystem consists of firms crossing different industries (by providing a range of products and services to their clients) and often includes both competition and cooperation between firms, but also fragmentation and interconnectedness (Iansiti and Levien, 2004).

From a servitization perspective, there are key advantages of providing servitization through an ecosystem. For instance, in contrast to mergers and acquisitions where organisations seek to transfer and integrate skills and knowledge into the acquirer's organisation, an ecosystem strategy allows the lead firm to avoid these risks (Williamson and De Meyer, 2012). Bustinza, et al. (2019) show that building a product-service ecosystem through collaboration with service providers can increase performance as a result of the superior knowledge-based resources of specialised partners. By distributing key resources, skills and knowledge in different parts of the ecosystem, members can draw on the benefits from members' unique abilities. Thus, an ecosystem can tackle more complex challenges and deliver more complex solutions, consisting of products and services such as noted earlier as PSS and IS.

Jacobides, et al. (2018) identified three streams of ecosystem literature. The first focuses on an individual firm or new venture, and views the ecosystem as a 'community of organizations, institutions, and individuals that impact the enterprise and the enterprise's customers and supplies' (Teece, 2007, p.1325). Here, the ecosystem is conceived as an economic community of interacting actors who all affect each other through their activities, considering all relevant actors beyond the boundaries of a single industry. The second stream considers focal innovation and the set of components (upstream) and complements (downstream) that support it, and views the ecosystem as 'the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution' (Adner, 2006, p.98). The emphasis is on understanding how interdependent players interact to create and commercialise innovations that benefit the end customer—with the corollary that if coordination within the ecosystem is inadequate, innovations will fail (Adner and Kapoor, 2010). The third stream focuses on a specific class of technologies—platforms—and the interdependence between platform sponsors and their complements. In this view, the ecosystem comprises the platform's sponsor plus all providers of complements that make the platform more valuable to consumers (Gawer and Cusumano, 2008). The platform ecosystem takes a 'hub and spoke' form, with an array of peripheral firms connected to the central platform via shared or open-source technologies and/or technical standards (which, for IT-related platforms, can be programming interfaces or software development kits).

While early research on IS focused on the firm as the unit of analysis, more recent research has focused on how integrators orchestrate a network – or ecosystem – of component suppliers and how innovation in external platforms might be driven by third parties within the ecosystem (Appio and Lacoste, 2019; Lehtinen, et al. 2019; Naghizadeh, et al., 2017). Conversely, PSS are comparatively less complex and are provided through a firm's internal platform. Karatzas, et al. (2016) discussed how a PSS provider used suppliers to provide services with new suppliers entering the ecosystem and under-performing ones potentially exiting the network (cf. Karatzas et al., 2017). As such the ecosystem for PSS is more likely to resemble a supply chain-like ecosystem – referred to as a hierarchy-based value system (cf. Jacobides, et al., 2018) - than traditional supply chains (Johnson and Mena, 2008). It is therefore postulated that:

Proposition 3a: To provide offerings and meet customer needs, both PSS and IS use ecosystems to access resources of specialised members within the network.

Proposition 3b: While PSS providers utilise a more hierarchy-based value system, IS providers use an innovation-focused ecosystem to meet complex customer needs.

Networks and ecosystems are formed of multiple stakeholders and have been shown, if effectively governed, to reduce and mitigate the embedded risks present in the delivery of PSS and IS (cf. Williamson and De Meyer, 2012). The linkages between risk and governance in PSS and IS is examined in the next section.

Theme IV: Risk and governance

The link between the customer and the supplier can be divided into five elements: goods, services, risk-sharing and risk-taking, access to or use of systems or infrastructure, and information (Normann and Ramirez, 1993). The high degree of risk involved in the provision and support of servitization offerings is due to the number of actors involved, their capital intensity and the interfaces with (complex) services (Davies and Hobday, 2005; Benedettini, et al., 2015). Moreover, a focal firm often works closely with suppliers and (certain types of) risks are quite often managed by and transferred to suppliers (Johnson and Mena, 2008). Here, PSS and IS research streams are similar in how risks are addressed.

In markets where product and/or service offerings are seen as relatively interchangeable, the buyer can exert control through a standardised procurement process, detailed specifications, contract terms and extensive monitoring (or the threat of it) to mitigate risks (Roehrich, et al., 2021). The purpose of clearly defined specifications is often to generate comparable offerings that can be exposed to competitive tendering (Lindberg and Nordin, 2008). Unique or highly customised IS offerings incur higher risk because they consist of fewer modular parts and often entail high-profile, large-scale procurement arrangements.

As discussed earlier, IS provision is a servitization trend that has also affected firms in more bureaucratically administered markets where the state (or regulatory institution) plays a key role at the expense of traditional market, price-based competition. Here, drivers for a move towards IS are manifold, but may include national prestige and interest in key technologies, dependency (e.g. on imports, foreign suppliers) or political needs to support a free-at-point of use policy (Hobday, 1998). Hobday (1998) states that 'often the degree of market contestability is low, as purchases depend on the policies of governments or nationally-owned purchasers (e.g. utilities) towards locally-owned and foreign suppliers' (p.20). In many countries, national control over markets such as nuclear power, telecommunications and aircraft is still the norm and ultimate risks (such as non-delivery or poor quality solutions) are often with the public sector. The typical commodity mass-market model (more common to PSS), where many buyers and sellers compete and adjust via entry and exit signalled by the emergence of dominant designs, are in contrast to markets for complex IS provision

(Naghizadeh, et al., 2017). In these settings, collaborative and more long-term interactions between firms allow buyers to feed their needs directly into the specification, design, development and manufacture of IS (Dyer and Singh, 1998; Windahl and Lakemond, 2006). Here, a more long-term, collaborative approach is often adopted to manage risks jointly in long-term relationships between partnering firms.

Similarly, within networks and ecosystems, firms rely on relational governance based on trust and social norms to manage and mitigate risks (Bastl, et al., 2012). This is in contrast to contractual control and emphasises the emerging (often more long-term) relationships between firms rather than contractual safeguards (Zheng et al., 2008). Where a situation requires greater levels of innovation, which is inherently uncertain and risky, there is a requirement to utilise these more relational governance mechanisms to manage emerging contingencies and risks (Lewis and Roehrich, 2009; Kreye, et al., 2015). Different risks may arise through emerging service demands that rely on a firm's successful adoption of technology to delivery digitalisation including Industry 4.0 and the Internet of Things (IoT) (Kohtamäki, et al., 2019). However, these new technologies may also help to manage and monitor risks. For instance, by using sensors to track a product's performance, PSS and IS providers can effectively analyse a client's usage trends and anticipate possible future difficulties with the product. This then triggers responses by the provider such as arranging a repair, replacement or product modification to ensure continuous performance from the offering.

To provide single- or multi-vendor solutions, systems integrators, such as the aircraft carrier alliance previously discussed, often utilise alliance and other partnering arrangements to align goals and tasks, as necessary for cooperation and risk management (cf. Gulati et al., 2012). Multi-vendor systems, which are far more common in IS, are assembled or integrated from 'externally' developed components (e.g., WS Atkins and C&W – Davies, 2004; 2006). Firms such as Alstom and Ericsson developed coordination capabilities to manage various tasks and activities, but also to deal with risks in the wider ecosystem. In such relationships, coordination - the alignment, adjustment and readjustment of tasks, processes and roles – is vital (Bastl, et al., 2019). Contractual governance mechanisms such as detailed contracts are costly and time-consuming to write (Roehrich, et al., 2020), and quite often do not include every single possible future contingency (Poppo and Zenger, 2002) and/or include every ecosystem member. This then leaves PSS and IS providers vulnerable to emerging risks. When risk is high (and services are more complex), there is a lack of contractual safeguards and control. Then governance within the ecosystem tends towards (contractual and relational) coordination and may emphasise the use of a more relational approach (cf. Roehrich and Lewis, 2014; Kreye, et al., 2015; Bastl, et al., 2019). Given the high level of uncertainty associated with IS and PSS, it is postulated:

Proposition 4a: While contractual governance mechanisms are important, they are often unable to address all uncertainties surrounding PSS and IS, and thus, risks are often managed via more relational governance mechanisms within the ecosystem.

Proposition 4b: The need for a PSS or IS provider to coordinate tasks, processes, activities and roles proactively within an ecosystem increases when risk and service complexity increases.

As risk increases within a network that provides PSS or IS, governing key relationships to achieve control, coordination and cooperation becomes crucial (Bastl, et al., 2019). This is examined in the following section.

Theme V: Control, coordination and cooperation

Prior relationship management (and especially governance mechanisms) studies have emphasised the need for firms to use formal control via (different types of) contracts to manage behaviours and mitigate opportunism and shirking (Cao and Lumineau, 2015; Essig, et al., 2016; Howard, et al., 2019. Recent research underlines the need for cooperation and coordination in the management of relationships (cf. Gulati, et al., 2012; Tee, et al., 2019). Control can be used when the units of exchange are standardised with low requirements for innovation and no intellectual property rights are in play (Williamson, 1981). Cooperation is mainly emphasised when there are alliance partners (i.e. a project) and the relationship is non-hierarchical (Gulati, et al., 2012). Control and coordination is often achieved by the individual or combined use of contractual and relational governance mechanisms across the relationship life cycle (Howard, et al., 2019).

Raddats, et al. (2019) argue that close relationships are a prerequisite for, or an antecedent to, more customised, integrated, process-orientated, and output-based service offerings. The management of relationships between firms is vital to ensure successful realisation of servitization (Tuli, et al., 2007; Kohtamäki et al., 2013). Bastl, et al. (2012) illustrate that parties in a servitization setting expected more open exchange of information and operational linkages to be strengthened. Similarly, the study by Raddats, et al. (2017) investigates the interactive development of capabilities for servitization from a dyadic perspective, emphasising the importance of strong interactions between partnering firms. França (2019) finds empirical evidence of the need to coordinate the various stakeholders in IS provision and their changing roles and responsibilities over the life cycle of a project. From a broader ecosystem perspective, Adner (2017) proposed that 'the ecosystem is

defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize' (p.42). Similarly, Jacobides et al. (2018) argue that an important but neglected characteristic of ecosystems is that they help coordinate interrelated organisations that have significant autonomy. The importance of coordination is confirmed by the fact that coordination failures could result in inefficiencies and possible relationship breakdown (e.g., Kalra, et al., 2021), thereby delaying or preventing partners from achieving their joint goals. Therefore, the ability to coordinate effectively the activities in a relationship, network and/or ecosystem would determine the effectiveness of PSS or IS providers.

The contractual and relational governance literature provides fruitful insights for servitization research. Governance research has focused on the role of hierarchies and formal contracts in coordinating partners' actions (Stinchcombe, 1985; Kapasali, et al., 2019) and the influence of informal norms, derived from societal, industrial, and professional institutions, on the interpretation of task interdependencies (Gulati, et al., 2012). More recent research has addressed contractual and relational governance mechanisms (Schepker, et al., 2014; Cao and Lumineau, 2015; Roehrich, et al., 2020) and the coordination between firms (e.g. Caldwell, et al., 2017; Tee, et al., 2019). While initial work focused on coordination within firms, subsequent research explored coordination between firms and the deliberate and orderly alignment and adjustment of partners' goals to achieve jointly agreed outcomes (Gulati, et al., 2012). The relational perspective on coordination has highlighted the role of individuals and groups, particularly managers, boundary-spanners and liaisons actively coordinating through relatively unstructured communication and decision-making channels (Gittell, 2002; Gulati, et al., 2012).

Oliveira and Lumineau (2017) identify two types of coordination activities. Steering activities involve goal-setting, enforcing and constraining-action, and are implemented by the firm through the use of more contractual mechanisms. Connecting activities are implemented by using more relational mechanisms through boundary spanners and integrators to monitor, engage and liaise with partnering organisations. Prior work has also pointed to a range of emerging (inter-) organisational forms to help coordination activities between organisations. For example, the study by Roehrich, et al. (2019) investigates the setup and use of integrated project teams (IPT) to forge closer and more collaborative relationships in IS provision. In IPT, the specialised knowledge and expertise found in partnering organisations are brought together – or integrated – in a cross-functional team with the authority to lead and execute projects (Huang and Newell, 2003). Cross-functional integration of knowledge depends on the second element of project teams – the creation of a team comprising different specialists to deal with common customers, clients, regions,

functions, processes, or products (Galbraith, 1973). The team structure depends on high levels of collaboration and trust to integrate different views, perspectives, and personalities.

In particular, the temporary nature of IS projects (Davies and Hobday, 2005) renders cooperation and coordination amongst key members within or across organisational boundaries and ecosystems riskier due to the limited time available to build cooperative norms and mutual trust amongst stakeholders. These projects may be characterised by possible governance challenges related to the shadow of the past (i.e. no prior joint work experience) and the shadow of the future (i.e. no future joint work). Such risks are mitigated when firms enter into new programmes and projects with firms with whom they are familiar (i.e. with an existing shadow of the past). Current examples of this are the main civil works contractors of High-Speed Rail 2 (HS2), such as Balfour Beatty and Vinci, who have 30 years of shared history, dating back to the delivery of the Channel Tunnel project between France and the UK. As indicated, project-based IS are often highly complex and unique in terms of capital resources, and coordination and close cooperation is required for multiple organisations. Conversely, due to the levels of standardisation and modularity in PSS (see Propositions 2a and 3a), control can be exerted by the focal firm for some products and services and, for the more complex, coordination can be deployed. As such, it is postulated:

Proposition 5a: Ecosystems for PSS and IS are orchestrated by the provider and utilise contractual and relational governance mechanisms for control and coordination.

Proposition 5b: PSS and IS providers utilise emerging organisational forms (such as IPTs) to facilitate cooperation between ecosystem members and emphasising shared decision making and knowledge exchange.

4. Discussion

Based on the propositions around the themes of modularity, platforms, ecosystems, risk and governance, this section synthesizes and discusses the five themes and their relationships in an effort to advance and conceptualise PSS and IS research. A further step in this process is the synthesis of these five themes into a theoretical framework (Figure 1).

< Please insert Figure 1 here >

The linkages between PSS and IS in relation to the five core themes are illustrated in Figure 1. It serves to show the interplay between each of the five themes addressed in this research and unpacks and highlights some of the differences embedded in the different types of servitization offerings, namely product-oriented, use-oriented and result-oriented PSS as well as IS. It is important

not to treat PSS as a homogenous concept and acknowledge the differences between basic product-oriented offerings (e.g., repair and maintenance contracts) and the most advanced and more complex forms of capability-type contracts (e.g., outcomes and result-oriented offerings).

For product-oriented PSS, it is argued that these offerings are largely delivered through internal platforms that function within an ecosystem. The difference in use-oriented PSS offerings lies in the more widespread inclusion of the wider supply chain and further deployment of service modules in order to meet customers' evolving needs whilst achieving efficiency through economies of scope. As the offering becomes more complex, there is a movement away from internal to external platforms.

There are key differences separating IS from PSS – such as the centralised control by PSS providers, who act as platform leaders and use their control of the platform of core products and complementary services to deliver value and attain sustained business performance for the firm. Providers of PSS decide how much modularity is needed, how open the interfaces should be and whether products and services are developed in-house or by external suppliers. Conversely, IS providers mainly deal with innovation processes while structuring the innovative activities of a growing network of external suppliers of complementary components, who are not fully controlled by one firm (Gawer and Henderson, 2007).

As the complexity of the offering increases, so does the inherent risk to the network involved in its use, delivery and support. This leads to a change from more contractual governance mechanisms focused on control to relational mechanisms focused on coordination and driving cooperation. In order to deliver IS effectively, process modularity is utilised while PSS uses product, service and information modularity. A further consideration for firms who are seeking to servitize, therefore, is the role of risk (Neely, 2008). Many studies are inconclusive as to whether the adoption of servitization leads to greater (Gebauer, et al., 2005) or lesser (Benedittini, et al., 2017) risks. However, risk can be mitigated by increasing coordination efforts between firms (Bastl, et al., 2019).

IS are often high-cost, engineering-intensive capital goods (and services) supplied in units of one or small batches, usually tailored to meet the precise requirements of each customer. The creation of IS often involves a high degree of product complexity and innovation (Hobday, 1998). Given the need to create unique or highly customised outcomes, IS providers compete on economies of repetition across projects (Davies and Brady, 2000), whereas PSS compete on economies of scale and scope. The focus here is on how to maximise the benefits by engaging (or being part of) a group of firms with complementary roles which will lead to the emergence of an ecosystem structure (Jacobides, et al., 2018). It is recognised that new models, concepts and frameworks are required to understand innovation through services (Chesbrough and Spohrer,

2006; Helkkula et al., 2018; Salter and Tether, 2006). In line with this understanding, IS can be conceived as an innovation-focused ecosystem enabled through external platforms.

PSS and IS research clearly identifies how product and service components of solutions can be modular and standardised (Baines and Lightfoot, 2014) and integrated into a common platform (Davies, 2004; Davies, et al., 2006). Platforms can be either internal or external to a firm and are arrangements of assets that allow complementary products and/or services to be developed (Gawer and Cusumano, 2014). The emergence and development of ecosystems also depends on modularity, specifically technological (or process) modularity (Jacobides, et al., 2018). In addition to process modularity, product modularity enables firms to obtain economies of scale and is important to firms wishing to servitize while improving their efficiency (Brax, et al., 2017; Rajala, et al., 2019). Moreover, modularity improves collaboration between interdependent firms when they are delivering complex systems (Tee, et al., 2019).

5. Future research opportunities

Having provided a synthesis and discussion of the five themes for PSS and IS research, a comprehensive set of future opportunities to advance theoretical and practical contributions to servitization research is synthesised. Table 1 details key topics to advance servitization thinking and practice in terms of modularity, platforms, ecosystems, risk and governance. These encompass several dimensions: exploring the nature and dimensions of key constructs (what); the myriad of actors involved in PSS and IS delivery (who); contextual and environmental conditions (where); temporal, change-related and process dimensions (when); and strategic and capability aspects (how).

< Please insert Table 1 about here >

Crucially, addressing these different questions in future research can help illuminate the core themes identified and propositions established in this paper. This provides a comprehensive and coherent collection of potential research areas, cutting across the five themes individually, their interactions and impact on PSS and IS delivery. Thus, further studies could conceptually deepen different dimensions and characteristics of PSS and IS, including customisation versus standardisation, degrees of repeatability, and the nature and boundaries of different types of platforms and ecosystems. This is vital for the development of a more common conceptual 'language' for servitization research across similar, yet (so far often) distinct, research areas. It also promotes cross-fertilization from neighbouring research fields (Davies, et al., 2018), such as

operations and supply chain management, project and innovation management, strategic management and industrial engineering.

Another important area for future research concerns the need to understand how individuals from different functions (e.g., engineering, management and legal) and hierarchies (e.g., operational staff and senior management) contribute to the delivery of PSS and IS. Research might also explore the myriad of different types of organisation (e.g., private, public and not-for-profit) forming the wider ecosystem. Different levels (i.e., from individuals to ecosystems) play a crucial role for both (different types of) PSS and IS. For instance, exploring individual job roles and behaviours will unpack how PSS and IS offerings are shaped by individual actors within the organisation and across the wider ecosystem. This is an area of research which has, so far, received limited attention in studies of servitization. Because of the nature of PSS and IS, with the importance of co-creating services, the questions of 'who is in, who is out, and who gets what' (e.g., in terms of actors in the ecosystem and value distribution across them) are particularly pertinent in cooperation set up to deliver solutions to clients. Moreover, given the nature of some IS including public sector participants, the need for social (rather than just economic) value creation (e.g., Caldwell, et al., 2017) needs further investigation.

Servitization – in the form of PSS and IS – is an increasing trend across industries and countries as evidenced in prior studies (e.g., Davies, et al., 2001; Baines, et al., 2009; Rajala, et al., 2019). Future work should take into account contextual factors such as industry dynamics (consumer versus capital goods), stages of production (low- versus high-volume) or technological uncertainty and their impact on PSS and IS delivery. Context impacts on the servitization strategies of individual firms, governance mechanisms (contractual and relational) and organisational arrangements (from integrated project teams and dyads to triads and the wider ecosystem involved in solution delivery). Temporal considerations with regards to the development stages of cooperation, and changes in and impact on the wider ecosystems could help to explore their impact on PSS and IS providers and the offered solutions themselves. Here, research should consider impacts of factors such as market or policy changes, new consumer/client demands such as sustainability/net-zero requirements, new (digital) technologies, socio-political changes such as Brexit or pandemics such as COVID19.

Research might also explore the various strategies deployed by servitization (PSS and IS) providers to develop capabilities to act on and react to these changes. Capability development and learning over a firm's multiple offerings, combining different knowledge sets from ecosystem members would add to our understanding of servitization. Here, research should consider (dis-) incentives (e.g., in contracts) for knowledge sharing and hiding. Future research might also consider how the modularity of processes enables (or hinders) cross-project (or cross-offering) learning to

facilitate economies of repetition. In addition, inter-organisational structures and hierarchies might be ambiguous for IS projects, as a multitude of firms, teams and individuals collaborate to achieve common outcomes (Chakkol, et al., 2018). Therefore, future research could explore how collaboration enables and establishes (procedural) routines to drive (different types of) innovation at the dyadic, platform, network or ecosystem level.

6. Conclusions

This paper analysed the similarities and key differences between PSS and ISS to establish propositions and advance a comprehensive research agenda on servitization. Building on adjacent research, it identified five themes (modularity, platforms, ecosystems, risks and governance) and explored their linkages with foundational work on PSS and IS. Bringing together these formerly distinct research streams resulted in researchable propositions and concepts to guide future research efforts in developing mid-range theory. This research outlined detailed future research opportunities to reconcile some of the differences between PSS and IS work and reconceptualise servitization research. This study should encourage future conceptual and empirical research to further augment scholar's theoretical understanding and the practical implications of servitization research and practice.

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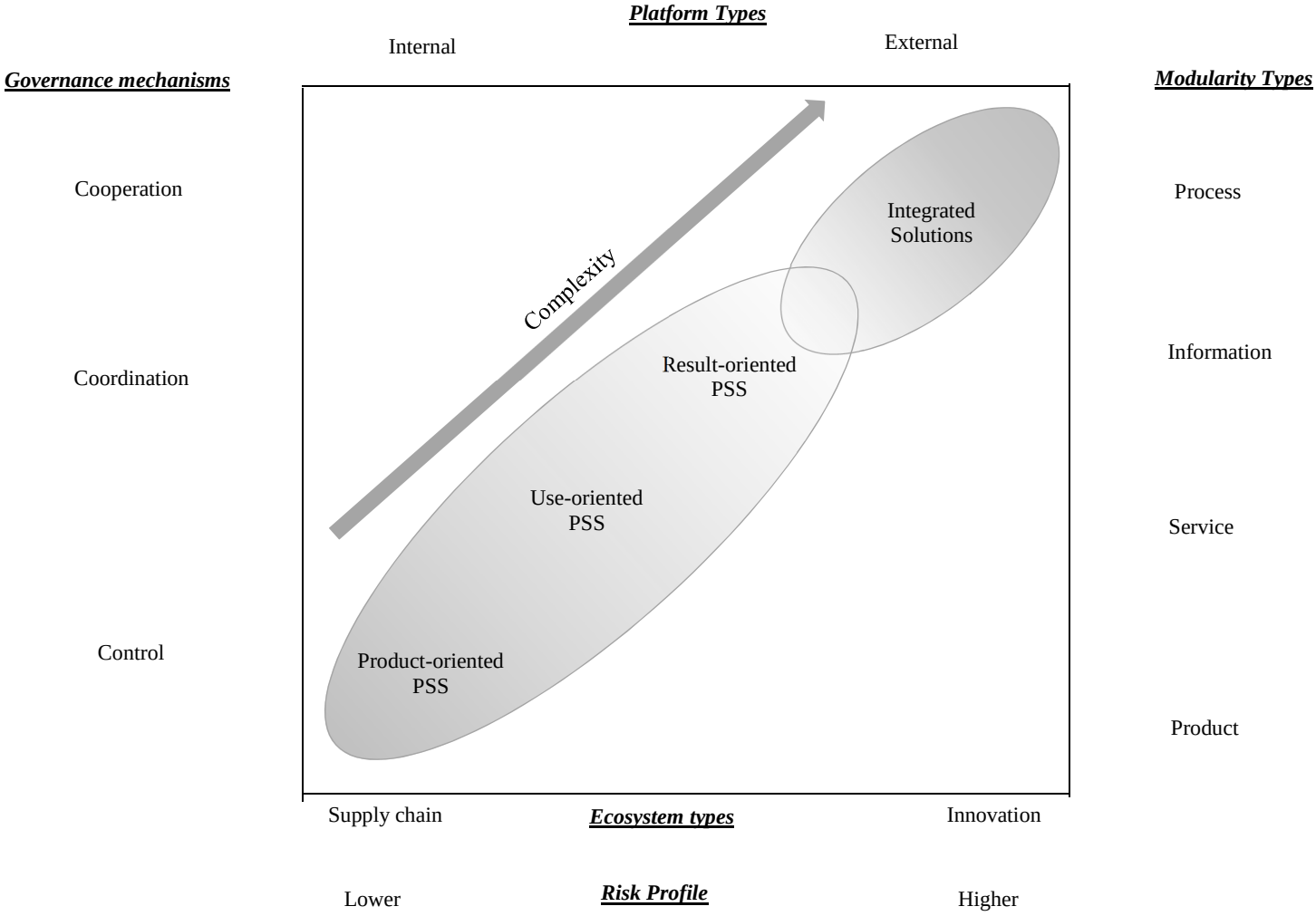

Figure 1 Establishing linkages amongst platform, modularity, ecosystem, risk and governance across PSS and IS

Table 1 An integrated research agenda for future servitization research

	What?	Who?	Where?	When?	How?
Key concepts/ factors	• Dimensions, commonalities and characteristics of PSS and IS (e.g. customisation versus standardisation, degrees of repeatability) • Dimensions and characteristics of a module, offering or component • Nature and boundaries (internal vs. external) platforms, modularity, networks and ecosystems • Characteristics and degree of conflicting goals and objectives between ecosystem actors • Legitimacy of new servitization providers • Characteristics of economic and social value creation and appropriation for solution delivery • Characteristics of a systems provider assuming a coordinator role	• Ecosystem: involvement of third/other parties (e.g., consultants), characteristics of ecosystem members, risk distribution and management • Inter-organisational: types of collaboration, shadow of the past, shadow of the future, integrated project team (IPT) • Organisations: size, contracting capabilities, relational capabilities, parties' (lack of) prior experience network/ecosystem coordinator role) • Individuals and teams: job roles, personal and professional interests, cognitive orientation, risk aversion, experience, bargaining power	• Contextual factors: socio-economic dimensions, informal institutions, environmental dynamism, technological changes, policy changes, legal institutions and system • Levels: individual, component, team, module, organisation, platform, dyad, supply chain, network, ecosystem, industry • Impact of diverse forms of environmental uncertainty	• Temporal considerations: phases of cooperation, phases of ecosystem and network development, roles and interplay of contractual and relational governance throughout the cooperation, phases of strong coordination needs, learning and coordinating activities and resources across the life cycle, critical events (including failures) in the relationship	• Strategies to develop, implement, and improve efficient servitization delivery • Developing and combining different strategic and operational capabilities including systems integration, resources, processes, and routines • Digitalisation of servitization offerings • Diverse approaches in dealing with value drift, and changes in the wider ecosystem impacting servitization delivery • Degrees of modularity of services • Management and transfer of (different types of) risks • Mitigating negative effects of close cooperation ('dark side'; including opportunism, conflicts, free-riding, lack of objectivity and redundant processes and routines)
Potential research questions (across themes and propositions)	• How does the use of modularity and platforms shape different dimensions of servitization offerings? • What are the key dimensions for PSS/IS standardisation (customisation), and what is their interplay? • What are key elements and characteristics of servitization's platforms, modularity, networks and ecosystems?	• How do individual employees' (e.g., managers, consultants, engineers, or lawyers) preferences influence servitization outcomes? • How does inter-personal and inter-organisational trust influence the development and maintenance of the wider supporting ecosystem? • How does the involvement of specific actors in the wider ecosystem impact its effectiveness in delivering servitization offerings?	• How is cooperation between servitization providers and actors in the wider ecosystem built and maintained in diverse institutional contexts? • How do characteristics of the specific environmental context, such as the legal system (e.g. maturity, enforceability) influence cooperation to realise servitization?	• How do different cooperation phases influence the nature of collaborations to deliver servitization offerings? • How does the relationship length and (lack of) prior experience influence the degree of cooperation in servitization delivery, networks and ecosystems?	• How are (different types of) contracts used in practice to control or coordinate relationships in servitization provision? • How is coordination achieved via contractual and/or relational governance mechanisms for servitization delivery? • How do cooperating firms counterbalance possible drifts in value creation over an extended

	What?	Who?	Where?	When?	How?
	• What is the impact of different degrees of conflicting goals between ecosystem actors on governance arrangements? • What is the impact of contract framing (e.g. promotion vs. prevention frame) on realising servitization outcomes? • How can new servitization providers increase legitimacy (from users, the broader ecosystem, or institutional environment)? • How are different dimensions of platforms created and managed? • Who is creating and appropriating economic and/or social value in servitization delivery?	• What are the determinants of ecosystem members' involvement in the delivery of servitization offerings? • Who is managing (coordinating) external platforms? • Who is managing what type of risk and who bears the ultimate risk? • Who is responsible for orchestrating the wider network or ecosystem for servitization offerings? • Who should be included in an integrated project team (IPT) to deliver servitization? • How and when are IPTs assembled and what is their impact on servitization delivery?	• What is the influence of certain contextual factors in the ecosystem development on servitization providers and their core relationships with suppliers? • How do regulatory and normative features facilitate or hinder (social and/or economic) value creation?	• When and how do partners develop and share mutual knowledge? • When do they hide knowledge? • What is the influence of critical events in the wider ecosystem on servitization delivery? • When and how do these events lead to coordination failures (and thus impact servitization delivery)? • When are unique capabilities developed and deployed in cooperation to deliver servitization offerings? • When and how are (parts of) ecosystems leveraged for the benefit of servitization delivery? • When and how do servitization providers draw on and integrate different knowledge bases from the wider ecosystem?	collaboration/servitization lifecycle? • Which (systems integration/servitization) capabilities are required to deliver digitalisation? • Which capabilities are required to manage risks in servitization delivery? • How does digitalization impact control, coordination and cooperation? • How do servitization providers manage and integrate different digitalisation business models? • How can firms develop modularity in their services as part of their offerings? • How do servitization providers mitigate the 'dark side' of closely coupled cooperation (e.g. trust breach and conflicts)?
Possible theoretical lenses	Framing theory, information processing theory, regulatory focus theory	Information economics, attribution theory, real options theory, strategic choice theory, prospect theory, reputation and power dependency theory, self-determination theory, relational exchange, extended resource-based view, social network theory/analysis, stakeholder theory	Institutional theory, law literature, international business literature, complexity theory, complex adaptive systems, panarchy theory	Dynamic capabilities, organisational learning theory / knowledge-based view, event system theory	Justice theory, fairness theory, capabilities, attribution theory, resource-based view, resource orchestration theory