Distributed manufacturing as an opportunity for service growth in logistics firms

Abstract

Purpose - The aim of the paper is to explore the changing role of a logistics service provider (LSPs) in order to better support their supply chain (SC) partners on their journey of advancing their product-service systems through distributing manufacturing around the world. The purpose of the paper is to investigate a novel route towards service growth followed by the LSP by integrating upstream into the value chain, and the resultant consequences in the configuration of the servitisation strategy, SC structure and allocation of roles.
Design / methodology / approach – A longitudinal exploratory case study design is followed. The case company is one of the world's largest LSPs.
Findings – The study highlights how companies can transition towards the development of service solutions when not following a uni-directional, downstream pattern of integration in the value chain. The findings challenge the established model of servitisation as a forward uni-directional process across the continuum from goods to a service-focused logic. They illustrate how companies can also move in a reversed direction, move possible back-and-forth, or extend and restrict their position along the servitisation continuum.
Originality / value - The study reveals that service transition involves a deliberate developmental process to build capabilities as firms shift the focus of their product-service offering. It provides novel empirical evidence of how the service growth journey can manifest itself in practice. With insights into the benefits and challenges of distributed manufacturing, it also highlights some of the opportunities available to LSPs to expand their product-service offerings, as well as some of the potential threats.

Key words: Servitisation; service growth; product-service system; distributed manufacturing; logistics industry.

Paper type: Research paper.

Introduction

The servitisation and service growth field is mature and has generated a considerable body of research. The general assumption is that companies move in either an evolutionary or a discontinuous manner from basic, product-oriented services towards offerings that include more advanced process-oriented services and product-service systems (PSS), leading ultimately to the provision of solutions (Kowalkowski et al., 2017).

Integrating products and service offerings constitutes a major managerial challenge, however, and is likely to require new strategies, new SC structures and new capabilities. Therefore, companies can follow diverse routes towards service growth with different consequences in the configuration of strategy, structure and resources. Understanding these alternative routes is essential, and two of the current issues that both academic and practice orientated literature focus on surround the continually evolving nature of service solutions along global value chains, and the changing roles played by various stakeholders along these supply networks.

These are dynamic issues and the challenge of how best to get multiple companies working together to optimise value delivery to market is an on-going quest for many organisations across sectors and around the world.

Up to date, the majority of the literature in the area of servitisation has focused on developing theory related to the process of combining products and related services. The emphasis is on firms positioned at one stage of the value system offering additional services that are or could be offered by other companies located further downstream into the chain, closer to the consumer market, hence enhancing the potential for increased customer value. However, a parallel stream of studies argue that the provision of integrated solutions is also attracting companies with a current base in services (Davies et al., 2006) and challenges the established model of servitisation as a forward uni-directional process across the continuum from goods to a service-focused logic (Finne et al., 2013). As such, companies can also move in a reversed direction, move possible back-and-forth, or extend and restrict their position along the servitisation continuum. The literature in this area is extremely scarce, with limited understanding as to how companies transition towards the development of service solutions when not following a uni-directional, downstream pattern of integration.

In addressing some of these gaps, distributed manufacturing has recently been highlighted as a strategy that offers immense opportunities for service growth and driving new service innovation. Also referred to as re-distributed manufacturing, it was defined by the EPSRC (2014) as "*technologies, systems and strategies that change the economics and organisation of manufacturing, particularly with regard to location and scale*". The phenomenon relates to an emerging move from global (offshored) to more local (near-shored) manufacturing, but also to a move away from large, centralised production to smaller, more dispersed (distributed) activities. It is perceived as "the shift from centralised to decentralised manufacturing with the aim to create a more resilient and connected system taking advantage of digital intelligence and newly emerging technologies, to provide an agile, user-driven approach that will allow for personalisation and customisation of products to local markets" (Moreno and Charnley, 2016). It enables shorter lead times and reduced risk of obsolescence, facilitating an agile response at reduced total SC costs. It could, however, also lead to more complex SCs, with a larger number of smaller, more flexible production systems being distributed around the world. Selviaridis and Norrman (2015) assert that it is vital in this regard that customers and manufacturers / service providers align their goals and incentives as well as their views on risk and reward sharing to best operate together. This is expected to lead to the development of new service solutions and changes to the roles that various service providers and manufacturing organisations may perform for each other, as well as the subsequent relationships that need to be developed to support this.

LSPs are particularly relevant in this context, with logistics today being among the most commonly outsourced activities by businesses. The logistics industry has been characterised by almost continual growth since its inception, which has even continued in global economic slowdown periods, but in recent years it is clear that its participants are facing substantial commercial pressures. This has been broadly due to the commoditisation of many of their core activities and the increasing competitiveness of trade lanes. Few barriers to entry combined with the fact that many of the more traditional LSPs find it hard to differentiate themselves in their marketplace, has led to a predominating feature in the sector of small margins in terms of returns on operations and investments (Vasiliauskas and Jakubauskas, 2007). This has had negative impacts on the customers for logistic services too, who are becoming increasingly concerned by, for example, the lack of innovation in logistics activities as LSPs concentrate too exclusively on just executing their contractual obligations (Cui et al., 2009). The future focus is placed on the need for end-to-end process excellence in the SC and leading LSPs should be positioning themselves to play an ever increasing role in the extended SCs, transforming from movers of goods to strategic value-adding entities (Jayaram and Tan, 2012).

In this context, as various SC tasks are increasingly distributed along the global SC and the need for managing decentralised activities heightens, new opportunities may occur for LSPs to develop innovative service solutions. Our study explores the changing role logistics companies can play to support their strategic partners on the journey of developing new service solutions in a distributed manufacturing context. In doing so, it challenges the popular conceptualisation of servitisation as the integration of activities downstream in the SC and illustrates how the re-design of the supply network and the re-allocation of roles by integrating further upstream into the value chain can aid a service growth strategy. An exploratory longitudinal case study of a global logistics provider is presented, spanning a period of four years.

Literature Review

This section provides a review of the literature in the service solutions field and highlights the importance of viewing the servitisation phenomena as a multi-directional SC process. It also introduces the concept of distributed manufacturing as an opportunity for logistics service providers to expand their product-service offering by integrating further into the value chain. Two research questions are proposed as a result.

Moving base into high value integrated service solutions

Servitisation has been defined as the transformational process of shifting from a product-centric business model and logic to a service-centric approach (Kowalkowski et al., 2017). Within this field, Kowalowski et al. (2017) argue that service concepts essentially refer to processes, offerings or practices. Related to this, the terms “service infusion” (Brax, 2005), “servitization” (Vandermerwe and Rada, 1988) and “service transition” (Fang et al., 2008) have been commonly used to denote processes of service growth. Furthermore, offerings that combine supplier and customer resources to create value in use are frequently referred to as “solutions” in the management and marketing literature (e.g., Macdonald et al., 2016). In many cases, solutions are based on high-technology and high-value goods or complex product systems (CoPS) (Davies and Brady, 2000); the practices of “systems selling” (Mattsson, 1973) and “solutions selling” (Doster and Roegner, 2000) are examples of using such offerings to drive change.

Kowalowski et al. (2017) argues that the terms *servitisation* and *service infusion* are more frequently used to denote service growth dynamics. They define service infusion as the process whereby the relative importance of service offerings to a company or a business unit increases, augmenting its service business orientation. To varying degrees, servitization or service growth involves a redeployment and reconfiguration of a company's resource base and organizational capabilities and structures (Baines et al., 2009); a redefinition of the mission of the firm; and a revamping of routines and shared norms and values (Kindstrom and Kowalkowski, 2014). A service business model means that the supplier commits to improving customers' value in use, assuming greater responsibility for the overall value-creating process as compared to product-centric, transaction-based business models. As established in the Oliva and Kallenberg’s (2003) path defining study, essentially the service transition concept assumes that firms undertake a unidirectional repositioning along a product-service continuum: from basic, product orientated services towards more customised, process-oriented ones, ultimately leading to the provision of solutions (Kowalkowski et al., 2015).

As such, Tukker and Tischne (2006) argue that the development of PSSs rests on two pillars. The first pillar relies on inherently taking the functionality or satisfaction that the user wants to realise as a starting point for business development. The second pillar highlights the need to elaborate the (business) system that provides this functionality with 'greenfield' mindset (instead of taking existing structures, routines and the position of the own firm therein for granted). Furthermore, Kowalkowski et al. (2015) emphasise that three prevalent and interrelated dimensions for the development of advanced service solutions can be identified in the literature: 1) from products towards process-oriented services; 2) from standardised towards customised services; 3) from transactional towards relational services. They argue that only when firms achieve a complete transition in all three dimensions, they are generally regarded as offering solutions rather than merely providing some basic and advanced services.

The majority of studies in the area of servitisation have focused on product-based companies increasing their service offerings. However, Vandermerwe and Rada (1988) argue that service sector companies can also servitise, just as firms may go in the opposite direction—that is, away from constructs associated with service provision. For example, logistics providers may adhere to a product-centric mind-set and business logic. Thus, Kowalkowski et al. (2012) point out that service-led growth and expansion is multi-faceted and does not necessarily imply a unidirectional development towards the provision of more extensive services. The service servitisation phenomenon has proven to be more multifaceted and multi-directional than the majority of PSSs and marketing literature frequently assumes (Tukker, 2004). Firms need to balance business expansion and standardisation activities, as they concurrently perform a number of roles, rather than switching serially from one role to another (Kowalkowski et al., 2015).

Furthermore, Brax and Visintin (2017) argue that the common logic observed in the majority of servitisation models is that as servitisation progresses, the offering becomes more complex for the provider, while usually decreasing the customer perceived complexity, hence increasing the perceived customer value of the exchange. The resulting *service solution*s, or solution offerings, are systemic hybrid offerings that combine capital goods and supporting services and are set out to optimise customer activities around a certain function (Brax and Jonsson, 2009).

New service solutions can also lead to a redistribution of roles between the parties involved. In contrast to extant product-centric views, Tuli et al. (2007) argue that solutions should be conceptualised as a customer-supplier relational process. However, this is commonly linked with the popular conceptualisation of servitisation as a shift of activities downstream in the SC (Davies et al., 2006). As opposed to this common view of servitisation, Davies and Brady (2000), Davies et al. (2006; 2007) discuss a series of case studies and discover down-stream as well as up-stream patterns. Davies (2004), for example, argues that there is increasing evidence in practice that firms are developing novel combinations of service AND manufacturing capabilities required to provide complete solutions to their customers' needs. The development of such new 'integrated solutions' requires a system integrator to advance their capabilities to design and integrate internally or externally developed components (products or services) while coordinating the activities of internal or external customers and suppliers (Prencipe, 2003). In this context, SC capabilities are defined as "practices to manage resources in the SC" (Aslam et al., 2020). As such, while Original Equipment Manufacturers typically extend their offering down-stream towards the end user by performing intangible, service-based activities such as understanding their customers' requirements, managing system integration projects and providing services such as customer care, advertising, billing, branding and marketing, system integrators were found to move further upstream. In this context, while integrating downstream meant adding more services to a firm's current offering by actively adopting a service growth strategy, integrating upstream involved increasing the role of tangibles in the firm's business model. This model of servitisation for firms that already have an established base in services provision remains largely unexplored in the operations management literature, particularly in terms of how LSPs might make use of it to strengthen their commonly weak position in the value chain. Research in service growth in other industries than manufacturing is needed (Davies, 2003; 2004; Kowalkowski et al., 2017) to ensure that we are not limiting our understanding of service to the biases and constraints that might be inherent to manufacturers.

The "distributed manufacturing" concept

The concept of "*distributed manufacturing",* also referred to as distributed production (Leitao and Restivo, 2000) or re-distributed manufacturing (EPSRC, 2014), has recently attracted increased attention in the academic literature (Srai et al, 2016; Kumar et al, 2020). Its primary attribute is perceived to be the ability to create value at geographically dispersed manufacturing locations situated in closer proximity to the final customer, hence enabling 'production on demand'. (Ko et al., 2001; Kumar et al., 2020). It is perceived as "*the shift from centralised to decentralised manufacturing with the aim to create a more resilient and connected system taking advantage of digital intelligence and newly emerging technologies, to provide an agile, user-driven approach that will allow for personalisation and customisation of products to local markets*" (Moreno and Charnley, 2016). The notion of "distributed economies" was also previously used to promote small-scale, flexible networks of local socio-economic actors using local resources according to local needs, in the spirit of sustainable development (Johansson et al., 2005). This transformation is largely enabled by digitalisation and advanced manufacturing technologies, such as additive manufacturing and Internet-of-Things (Ford and Minshall, 2015).

As such, enabled by advanced manufacturing technologies, the concept revolves around the changing location and scale of production activities, such that manufacturing units are of greater number, and therefore relatively smaller, and are located closer to the consumer of the final product (Matt et al., 2015). It can thus be related to a shift from global (offshored) to more local (near-shored) manufacturing, but also to a move away from large, centralised production to smaller, more dispersed (distributed) activities performed closer to the customer. Therefore, distributed manufacturing does not only imply a change in manufacturing location, but also a fundamental reconsideration of the scale of the operation, performed nearer to targeted consumers. This is in stark contrast to established concepts such as back-shoring / re-shoring, seen as the re-concentration of parts of production from own foreign locations or from foreign suppliers to a domestic production site of the company (Moradlou et al., 2017).

Along the same lines, Srai et al. (2016) view distributed manufacturing as a new paradigm with a location element, a value element and a technology element, hence leading to a redistribution of value creation sources, where the OEM and specialist actors are less dominant. The resulting distributed production networks are organizational systems more able to match both the speed and the efficiency necessary to compete in today's global markets. Hence, the notion of distributed production conceptualizes a shift in consumption and production patterns away from conventional mass production and its long, linear SCs, economies of scale and centralizing tendencies.

The boundary between consumers' and producers' roles in these networks also blurs and the intermediaries between them disappear or transform as production takes place closer to the point of consumption (Kohtala, 2015). As a result, distributed manufacturing ultimately aims for flexibility, speed, agility and greater customer orientation in manufacturing, moving towards mass customization (Leitao, 2009) in a more de-centralised production set-up. It follows an agile and user-driven approach that allows the manufacturing of personalised products at multiple scales and across dispersed geographical locations (Moreno and Charnley, 2016). Matt et al. (2015) argue that the heightened recent interest in distributed manufacturing has been driven by a number of factors including advanced manufacturing technologies, rising logistics costs, changing global economies, pressures for reduction in time to market.

Srai et al. (2016) highlight that distributed manufacturing, while implying a greater number of dispersed locations of manufacture, can change the nature of the value chain, with potential implications for markets, organizational structures and distribution networks. The authors propose five characteristics of distributed manufacturing:

1. Digitalisation – permits a product to exist perpetually in a virtual form, ready to be physically rendered at any time. Production can take place anywhere, given the local availability of resources and access to new production technology;
2. Localisation – small-scale distributed operations permit the location of production facilities closer to the potential user;
3. Personalisation – a direct consequence of digitalization, it facilitates the modification (both subtle and extensive) of physical products. Opportunities for customization, collaborative production and integrated products are increasingly user driven;
4. New production technologies – due to their agility and ability to operate at small scale, these technologies permit a proliferation in the number of production sites, as well as less restrictions on where they might be located and
5. Multi-user participation – new possibilities for the user emerge, who not only has an enhanced interactive role but also agency in the manufacture of the product.

The emerging changing nature of the distributed manufacture value chain highlighted above offers immense opportunities for service growth, as well as driving new service innovation. This, in turn, is expected to require the development of new capabilities along the supply network and to lead to a potential re-allocation of roles along the current value chain (Fleury et al., 2007). As such, using distributed manufacturing as the key focus for our study and Kowalkowski et al.'s (2015) theoretical framework of three dimensions for the development of advanced service solutions, two research questions are put forward:

Q1: How do organisations in the logistics sector configure their service growth strategy?
Q2: What is the impact of their new value proposition in terms of developing new capabilities and activities?

Research Design

Longitudinal case study approach

To answer the two research questions, we adopted a single longitudinal case study approach. The study was conducted between 2014-2017. A case-study research approach was favoured for two reasons. First, case studies have been extensively used in recent studies of integrated product-service offerings within the production and management research (Durugbo 2013). Karlsson et al. (2018) consequently argues that case studies enable an opportunity to capture how PSS innovation capabilities are considered in a SC, as such a question deals with operational linkages that need to be traced over time rather than mere frequencies. Second, the case study research methodology enables further understanding of phenomena that can be difficult to study in other ways, e.g. through a survey (Yin, 2014), as a case study is better adapted for studies deeply embedded in rich empirical data (Eisenhardt, 1989), while achieving depth and detail in the investigation. It also allows the capture in detail of the context surrounding the phenomenon (Barratt et al., 2011). This is consistent with the literature, which has relied on single case studies for maximizing learning about similarly complex phenomena where prior knowledge was limited (Pellinen et al., 2016). Moreover, Yin (2003) highlights that single cases are appropriate when an 'revelatory' case is observed, where the phenomenon of interest (service growth through upstream integration) has a high degree of visibility (through the company's competitive strategy) and which offers ample opportunities to gain complex insights into real life situations (Eisenhardt, 1989) and learning (Binder and Edwards, 2010).

The longitudinal design provided an opportunity to investigate the development and implementation of the innovation project in its shared context within a given time range. It also helped to examine how the case company had developed its value propositions within its product-service system (Chakkol et al., 2014), capturing the dynamics and complexities of the involved interactions and developments over time (Smith et al., 1995). The purposeful selection criteria was also balanced with pragmatic concerns regarding the broader SC actors' willingness to participate in the study (Gosling et al., 2016) and the opportunity of wide access to a large amount of data due to one of the authors being embedded in the focal company over the period the case study took place.

Thus, a phenomenon driven research approach (Schwarz and Stensaker, 2014) was followed based on a phenomena grounded in observations of practitioners doing something different from what we would expect from the literature knowledge base (Eisenhardt, 1989) – in our case, a LSP developing a service growth strategy and in-house manufacturing capabilities by increasing the role of tangibles in their business model and the service solution offered.. In summary existing literature (service growth, distributed manufacturing SCs) was used to position the findings as different from current knowledge in an aim to generate new theory built inductively, based on an understanding of the phenomena that is generated from empirical data (Schwarz and Stensaker, 2014).

Company focus

The research focused on the logistics provider, *LogProd*. LogProd was chosen as a result of its recently developed business model aimed at offering a new service solution based on increasing the role of tangibles in the firm's business while enabling their SC partners to distribute manufacturing around the world. LogProd was one of the world's leading multi-national providers of SC solutions combining its core services of Air Freight, Ocean Freight and Logistics to deliver globally integrated, tailor-made end-to-end service solutions. It employed around 16,000 people worldwide, operated a global network with 500 offices in more than 80 countries and worked with partner companies in a further 80 countries. Two of their key strategic partners involved in developing the new solution (The Shipper, a global supplier of telecommunications network equipment, and The Customer, a telecommunications services provider) also formed part of our investigation. *The Shipper* was a leading global provider of information and communications technology infrastructure and smart devices. It offered integrated solutions across four key domains: telecommunication networks, IT, smart devices and cloud services. It employed over 180,000 people at 50 different locations around the world. The division our study focused on was located in China and manufactured base station boards, with one of their main customers located in Brazil. *The Customer* was a large telecoms company located in Brazil, with *The Shipper* as its main supplier.

Data collection methods

Data collection methods employed unstructured interviews and verbal narratives, presentations, documentation and archival records to capture the company's journey towards developing a distributed manufacturing solution over a period of four years (2014-2017). Due to the highly exploratory nature of our study, open-ended interviews were conducted (Eisenhardt, 1989), using a series of constructs as interview prompts, which were developed following the literature review stage of our study: indicative examples of open-ended interview prompt terms used are presented in Table 1.

Product-service systems	Distributed manufacturing
• Service functionality • Business elaboration, • New capabilities • New roles	• Digitalisation • Localisation • Personalisation • New product technologies • Multi-user participation

Table 1. Indicative open-ended interview prompts

Thirteen interviewees were selected from the participating senior management teams to obtain an un-biased view of the phenomenon under investigation (see Table 2). The criteria for selection were their area of responsibility, as well as knowledge of the project and expertise. Each discussion lasted from 30 minutes to 4 hours. The interviews were aimed at understanding how the new service solution was implemented. In some instances, follow-up interviews were also conducted to gain deeper insight into certain aspects and to resolve any ambiguities. Primary data collected through interviews was supplemented with secondary data, such as company reports and various internal and external communications, to enable triangulation of the findings and enhance the credibility of the study (Yin, 2003).

No	Interviewee Position	Year of Interview			
		2014	2015	2016	2017
1.	Business and Market Coordinator (LogProd)		X	X	
2.	Chairman of the Board of Directors (LogProd)				X
3.	Research Leader, Chair of Research Centre (LogProd)	X	X	X	X
4.	Corporate Optimization and Analytics Manager (LogProd)	X	X	X	X
5.	Global Head of Logistics and Manufacturing (LogProd)	X	X	X	
6.	Global Head of Logistics Solutions (LogProd)	X			
7.	Global Head of Strategy and Innovation (LogProd)	**Twice Annually, 2014-2017**			
8.	Global Head of Supply Chain Solutions (LogProd)	X			
9.	Global Key Account Manager (LogProd)	X	X		X
10.	Logistics Manufacturing Services Analyst (A) (LogProd)	X	X	X	X
11.	Logistics Manufacturing Services Analyst (B) (LogProd)			X	X
12.	Logistics Manufacturing Services Manager (*Shipper*)	X			X
13.	Logistics Manufacturing Services Manager (*Customer*)		X		X

Table 2. Interview participants

Data analysis methods

Data analysis employed open, axial and selective coding, in accordance with Miles and Huberman (1984). Axial coding was first employed to organize the vast amount of data collected (over 40 hrs of interviews) into higher-level concepts (such as Product-Service System, Distributed Manufacturing). A constant comparison process helped integrate new interview data with data from previous observations and interactions. The second step involved open coding and identification of trends and themes in the collected data, as reported in the Findings section below. Table 3 presents a sample of the coding process followed. In addition, investigator triangulation was used to improve the validity of the coding process, which meant cross-checking the results from the analyses by different investigators (Denzin, 1989). Joint discussions amongst the research team resulted in checking and validation of first-order categories and, where necessary, interviewees were contacted via phone or email for further clarification. To ensure further reliability of the data, drafts were presented to the interviewees. No major revisions were required.

Raw data	Final codes	Higher-level concepts
"We experience increasing demand for personalized products and a movement away from globalization to localization, shorter lead-times and an increasing number of smaller shipments ; so our own ability to innovate and bring new products and services to market is key to our long-term value creation".	Localisation Business elaboration New capabilities Emerging value proposition	Distributed manufacturing Product-service system
"we receive the components from the supplier, and store the components by [LogProd]'s facilities; we assemble the components into the final product and send to the customer, but also in some cases we wanted to do installation as well".	New roles New capabilities Business elaboration Service functionality Key activities Emerging value proposition	Product-service system

Table 3. Sample coding

Considering the longitudinal nature of the case, data analysis took place in parallel to data collection and, as common threads began to emerge, they were compared with the rest of the already transcribed interviews (Kembro and Selviaridis, 2015). As a result, insights from the conducted interviews were brought up in the remaining interviews to receive additional comments to confirm or contest a common thread. This was an iterative process, where the analysis began simultaneously with the gathering of the data and continued throughout the data collection process and beyond (Ellram, 1996).

Four key measures for establishing the validity and reliability of case research (McCutcheon and Meredith, 1993; Stuart et al., 2002; Yin, 2014) are summarised in Table 4, with a description of how each has been addressed.

Evaluation criteria	Actions taken across phases of research			
	Research design	**Case selection**	**Data collection**	**Data analysis**
Construct validity (establishes correct operational measures for the concepts being studied)	Developed a protocol using a range of interview prompts (Table 2) based on the extant literature and a priori theoretical lens	N/a	Piloted the protocol with two interviewees; multiple sources of evidence; interviews conducted with leaders across a range of positions in the focal company as well as a representative from The Shipper and The Customer at the outset and close of the research period.	Informants' validation of case study report; obtained feedback from fellow researchers on case analysis
Internal validity (establishes a causal relationship, whereby certain conditions are shown to lead to other conditions)	Established the evidence from the literature. Confirmed with focal company leaders and their Shipper and Customer the main findings from the research	Uniqueness of case; Data access; Embedded researcher	Multiple informants; triangulation supported by secondary data from websites and corporate reports (or equivalent)	Pattern matching
External validity (establishes a domain in which the study's findings can be generalised)	Used replication logic (i.e. replicate on analytical rather than statistical generalisation)	Carefully selected Interviewees, including referrals from the 1st to the 2nd interviewee	N/a	N/a
Reliability (demonstrates that the operations of a study can be repeated with the same results)	Developed a case study protocol	N/a	Provided interview brief to all interviewees before the interview; developed a case database (transcripts, quotations, matrix, codes, etc.)	Involved another researcher who did not collect the data; two scholars were involved in the development of coding

Table 4. Summary of research credibility (adapted from Yin, 2003; Fan and Stevenson, 2018)

Case study findings

To structure our case study's findings, Kowalkowski et al's (2015) three prevalent dimensions of service transitions were used: 1. From product towards process-oriented services; 2. From standardised towards customised services; 3. From transactional towards relational services.

1. *From product /standardised service towards process-oriented services*

LogProd's main expertise was in freight forwarding, with a long tradition of success in two core product offerings: Air freight and Ocean freight. In 2011, LogProd decided to expand its service offering by adding Logistics as a core product, giving its customers an end-to-end LSP solution. To launch the new logistics product, a new team was recruited, investments in IT tools and services were made and a new strategy was developed.

> *"Logistics or 'Contract Logistics' is now a commodity and basic logistics functions which were once seen as specialised are also commoditising... The opportunity we identified was to move our services further along the value chain" (Global Head of Logistics Solutions, LogProd).*

The new strategy made a clear distinction between traditional logistics services being offered (basic storage and handling of products) and logistics Value Added Services (VAS), where the emphasis was on providing services that added value to the customers' product through transformational activities, such as kitting, assembly and configuration, traditionally located further upstream the value chain. LogProd's logistics strategy aimed to avoid growth by offering traditional logistics services alone. It focused instead on providing, wherever possible, only logistics VAS.

As the logistics business began to increase its profit, a larger team was recruited to expand the VAS offering. The recruitment was centred on skilled manufacturing managers with experience in Hi-Tech manufacturing, rather than managers with a freight or logistics background. This recruitment policy introduced a new skill-set into the organisation, both in terms of a deep understanding of current technology customers' SCs, but also in the principles of manufacturing business excellence and the importance of time-compression in SCs.

At the opening of a new logistics facility for a major technology customer in Brazil, LogProd's logistics team, drawing on the additional manufacturing skills recruited into the business, identified the opportunity to completely re-design the customer's 'traditional' SC model. This was the inception of the new servitisation strategy which was termed 'The Logistics Manufacturing Solutions' (LMS) model, and the starting point for our case study.

The traditional supply chain model

The centralised SC model traditionally employed by LogProd's shipper in the technology sector originally emerged due to the availability of low cost labour in certain countries, most notably in China. As manufacturers moved to these countries, material and component suppliers also moved to these locations. This created a 'campus' mentality and an ever-increasing centralisation of manufacturing in one location, usually the lowest labour cost location available.

One of the main characteristics of this SC model was a clear division between manufacturing and logistics. The Shipper built telecommunication base-stations with personalised software uploaded onto during the manufacturing process in China. Typically, nearly all of the manufacturing process, from surface mount (SMT) or complete knock down (CKD), configuration, final assembly and test (FAT) were carried out in one large manufacturing location. Once FAT was completed and the final product fully configured, it was then sent to a logistics focused location, often operated by LogProd (as the LSP) for final pick, pack and delivery to The Customer. The typical split of manufacturing services (provided by the Original Equipment Manufacturer - OEM)) and logistics services (provided by the LSP) is visualised in the image below (Figure 1).

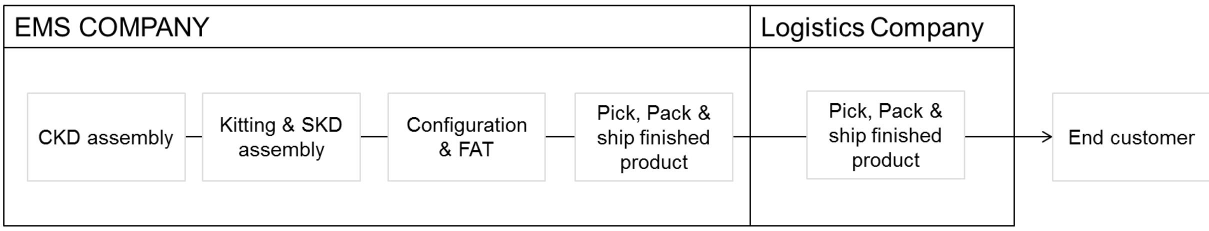

Figure 1. The Traditional Supply Chain Model

Some of the advantages of the traditional model were associated with the centralisation of all manufacturing in one location (China) by The Shipper. However, The Shipper increasingly needed to be able to provide their final consumer companies, located all over the world, with the very latest hardware and software (which could change from one day to the next) and customise products and deliver them quickly, once ordered, in the most efficient manner. In this context, centralised global SC models did not appear to provide either the required speed to market, or the ability to reduce the high obsolescence costs.

The long lead times incurred in assembling the final product, uploading the latest technology and software onto it in China and then dispatching it to the final consumers meant that by the time the product reached consumers' locations across the world the base-station was out-of-date. The Customer would have already made several requests for updates during the time the product was in transit, which most often could not be accommodated. This led LogProd to prompt The Shipper that, for the SC to remain competitive, it needed to be re-designed to allow for postponing the final configuration closer to the customers. A new model was required that allowed them to personalise their products with the latest technologies and software, as close as possible to the consumer markets. LogProd argued that they were ideally suited to be able to bolt these additional services on to the traditional services they provided for The Shipper.

> *"With LogProd's global footprint of warehousing and distribution facilities in major markets, we are ideally suited to assist with the tail end of the manufacturing process, before the products are shipped out to customers. With investment in production expertise, we can assemble goods, run software updates and tests for technology customers. This drastically reduces overall lead time for customer orders, reduces inventory levels and improves on-time delivery service levels" (Global Head of Strategy and Innovation, LogProd.*
>
> *"We can call off components, manufacture and ship in one day… The configure-to-order process we now perform customizes the product as late as possible in the supply chain. It allows materials to be allocated against orders only when required in the order fulfilment process. With this postponed manufacturing approach, our customer can significantly reduce working capital requirements and order fulfilment lead times" (Logistics Manufacturing Services Manager, Shipper).*

Servitisation - The Logistics Manufacturing Service (LMS)

In 2014 LogProd and The Shipper developed a new SC model as a result, which they called The Logistics Manufacturing Service (LMS), as seen in Figure 2. In this new model, rather than The Shipper, as a manufacturer, centralising production in one location, LogProd proposed that as many manufacturing operations as possible needed to be postponed as late as possible in the SC. To allow for higher levels of personalisation more efficiently and faster delivery lead times to customers, these operations were to be performed at nine global locations, as close to the end user as possible.

> *"… Now the lead time is reduced to 8 weeks or so (it used to be 24 weeks previously), so it is a massive reduction in lead time… That reduction in lead time is the major factor in the success of this new service (Logistics Manufacturing Services Analyst B, LogCom)".*

What first differentiated this proposed model from the more 'traditional' SC was the fact that only the CKD activity was to be carried out in the customer's central manufacturing location in China. The remaining core manufacturing processes, typically the specialism of the electronics manufacturing company (The Shipper), such as box build, kitting, configuration, final assembly and testing were to be carried out by LogProd itself in nine dispersed own logistics facilities distributed across the world (Brazil, Dubai, USA (E and W), Mexico, Germany, Eastern Europe, South China, Singapore). As a result, LogProd, who already had a physical presence into these markets (as warehousing facilities) began investing into developing manufacturing capabilities targeting more advanced service solutions, which enabled them to transfer the final assembly and software upload activities in-house from The Shipper.

> *"Our Dubai South facility is the customer's first distribution centre, globally, that unites hardware assembly and software load under one roof" (Global Head of Supply Chain Solutions, LogProd).*

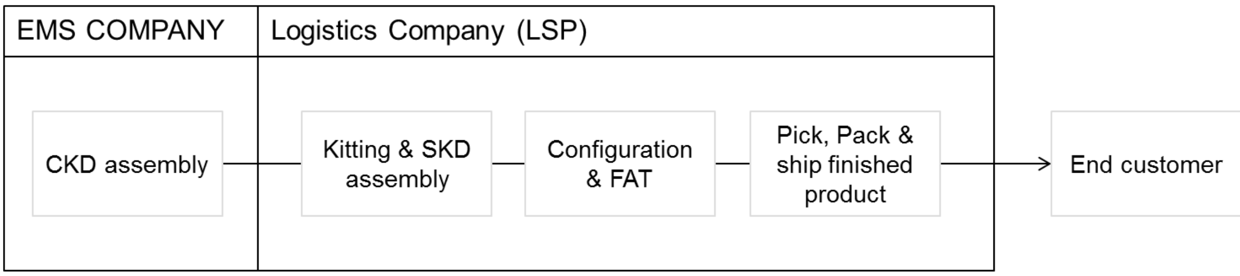

Figure 2. The New LMS Supply Chain Model

By 2017, an appraisal of the new model implemented in collaboration with The Shipper and The Customer along the supplying pipeline in Brazil (one of the nine new supply pipelines) highlighted significant improvements. For example, as products were held in a semi-assembled state, closer to the customer demand point (Brazil) and final assembly was made to order, the overall lead time (measured from customer order to customer delivery) was reduced from 90 to 15 days. Finally, as products were configured and assembled to order for The Customer in Brazil, there was less requirement from The Customer to accommodate last-minute changes, which previously resulted in obsolete configurations and wasted materials. As a result of the changes, cabling material scrap costs, for example, reduced by 20%.

> *“We take full ownership of the whole process – from planning to quality control and delivery... Our partnership has evolved greatly in the past five years. We started off with a spare parts logistics operation and have now moved into manufacturing” (Global Key Account Manager, LogProd).*

Overall, by 2017 the focal company was reporting a rise in profit across its global operations by 9.89% and an increase in net forwarding revenue by 6.48%, the highest improvement on its financial figures for the past decade (LogProd Annual Company Report, 2018).

The participating companies also highlighted that the adoption of the distributed manufacturing model as an LMS provision was enabled by a set of factors. The main one was *Cost considerations*, mainly due to manufacturing companies increasingly reviewing the total SC costs which initially motivated their move towards centralised manufacturing in low-cost labour locations. This review was driven by a number of secondary drivers, such as: *Levelling of global labour costs & the impact of automation; Levelling of energy costs; Increased political and government subsidies and a rise in the threat of tariffs.* The adoption of the new model was further motivated by an *increased perception of risk from SC disruption.* A risk of having all manufacturing in one location and far from customer demand was the perceived commercial impact if the SC inbound-to or outbound-from the point of manufacture was disrupted. Recent political instabilities (such as riots, terrorist attacks or embargos) or environmental catastrophes (such as tsunamis or earthquakes) had also prompted organisations from LogProd’s SCs to rethink the risks to their business if they were reliant on a small number of manufacturing facilities that were far from customer demand. The recent Covid-19 crisis has further heightened the importance of thinking through SC resilience and risk of disruptions.

The new c*ompetitive landscapes and changing customer demands was another factor.* Technology providers that cannot provide the latest product, technology or software at the same speed as their competitors are likely to lose sales. For large companies, this problem is compounded as information, ideas and technologies are more quickly developed and brought to market (examples include additive manufacturing, nanotechnology, advances in power supply technology), which allows smaller, more specialised manufacturers who are able to adapt and respond more quickly with innovative technology and manufacturing processes, to successfully compete with larger, more established companies.

2. From Standardised towards Customised Services

Based on the case study findings presented above, the changes in value propositions, roles and capabilities along the value chain and improvements made by LogProd to set-up the new Logistics Manufacturing Service model are summarised in Table 5 below.

Traditional supply chain model	LMS Model
• Manufacturing processes and logistics processes were carried out independently and as two separate operations: 100% of final assembly processes carried out at The Shipper's centralised manufacturing facility; logistics solutions provided by LogProd globally.	• Final assembly processes were brought in-house by LogProd at dispersed global locations and combined and integrated with already existing logistics processes in local markets; • Final assembly carried out as close as possible to customer demand points
• Build to stock processes (products pushed from manufacturing).	• Products stored as components at LogProd's facility and assembled (pulled) to The Customer's order.
• Planning and scheduling defined and pushed by manufacturing processes; • Logistics functions work on traditional productivity measures (i.e. fill-rates), with a focus on keeping everyone busy.	• Planning and scheduling carried out by the LMS team at LogProd, based on The Customer's demand rather than manufacturing output; • Focus on capacity and bottle neck management and application of the theory of constraints;
• Separate manufacturing and logistics KPI's.	• LMS KPIs defined, covering both logistics and manufacturing processes (as illustrated above).
• Product quality checks carried out at manufacturing plant.	• Product quality built into the final assembly process, ensuring final checks carried out as close as possible to final customer delivery.
• Most recent software uploaded at manufacturing plant in China (24 weeks lead-time).	• Most recent software uploaded at facility managed by LogProd globally, ensuing the most recent software is uploaded before delivery to The Customer (8 weeks lead-time).
• Final customer configurations carried out at manufacturing plant in China. This can result in customer requesting changes after the product has left the manufacturing facility in China. In this case, the product needs to be returned from to China to be re-configured, or specialists from the manufacturing plant need to travel to the logistics facility to carry out the configurations.	• Customer configurations carried by LogProd in proximity to final market. The result is that customer configurations are carried out much closer to the point of customer demand, resulting in reduced requests for last minute changes between order and delivery.
• High levels of working capital.	• Decreased working capital, as value not added to the product until later in the SC; • Product held as components, not finished inventory, reducing working capital.
• Standard returns process, where products are returned to manufacturing plant in China.	• Returns can be repaired directly by LogProd locally.
• Spare parts inventory held both in manufacturing plant and in spare parts field (2 separate locations lead to increased safety stock).	• Spare parts inventory and manufacturing supplies combined at various LogProd's facilities, reducing overall inventory levels.

Table 5. Operating changes before and after the introduction of LMS

3. *From Transactional towards Relational Services*

Even though the changes in business model made so far, enabled by the factors highlighted above, have had a dramatic impact on the overall SC performance, the participating companies believe the distributed manufacturing concept has the potential to bring further changes and opportunities for improvement to SC design, both in the technology sector and in other sectors. One such change is the encouragement of innovation and investment in micro-manufacturing technologies, such as additive printing, which can now allow parts to be manufactured directly in more local to the end customer facilities, and often logistics facilities which are already local to the customer present an ideal opportunity for this re-location. This will mean that a higher proportion of value-add manufacturing could be performed by the LSP, who would carry on integrating upstream into the value chain.

The new model also enables LogProd to gain increased visibility along the value stream, including bill of materials details, detailed order profiles and return and repair flows. As a result, LogProd is now in a position to provide more advanced forecasting solutions to its customers, to the benefit of the entire SC. Further integration of LMS activities with repair and return activities could also take place. LogProd have recently established repair and return centres inside their LMS facilities. The benefit is that repairs can be carried out in the logistics facility (rather than shipping back to the central manufacturing plant in China) and also parts and components from the LMS activities can be used in repair processes – reducing the overall inventory required. The integration of LMS activities with spare part management activities could also take place. Similarly, as components are stored in the LMS facilities rather than at the central manufacturing facility, there are more opportunities for economies of scale further downstream the SC.

Furthermore, an opportunity for multi-customer LMS shared facilities now exists, where industry-common manufacturing activities (final configuration and kitting, testing) can be carried out for more than one customer in one LMS facility. This would reduce costs but also encourage knowledge sharing across various value streams. It would also lead to an ability to increase the speed of reverse loop SCs. Specifically, with the knowledge gained by LogProd on manufacturing products close to local demand, LogProd also developed additional capabilities that allowed it to be able to repair and remanufacture products in the local market. As such, this enabled LogProd to offer a new range of services, and helped The Shipper to increase the speed with which products were repaired and returned into the SC.

Following the adoption of the LMS model, the SC has remained as global as before, with raw materials and components still purchased from far away locations. However, local procurement opportunities have now opened up, with components to be potentially sourced closer to customer demand. This could further reduce inventory levels (as components will be stored closer to customer demand) and increase speed to market.

Discussion

From a strategic perspective, our study highlights that Tukker and Tischne (2006)'s two pillars that the PSS rests on are just as valid in a servitisation strategy where firms transition towards developing advanced service solutions by integrating upstream into the value chain. The first pillar relies on inherently taking the functionality or satisfaction that the user wants to realise as a starting point for business development (in our case, quicker access to the most up to date technology). The second pillar highlights the need to elaborate the (business) system that provides this functionality with a 'greenfield' mind-set (instead of taking existing structures, routines and the position of the own firm therein for granted) – in our case a LSP that enables the implementation of a new distributed manufacturing supply network and develops a service growth strategy to assist its implementation by increasing the role of tangibles in their business model.

As such, the main findings from our study show that the emergence of distributed manufacturing services has important implications for the design and management of the associated supply networks (Dotoli et al., 2005). A redistribution of roles among the SC actors is likely to occur (Srai et al., 2016), and this could provide a great opportunity for companies in the logistics sector, as well as other actors, to provide innovative new services solutions and strengthen their position within the value chain and potentially beyond in the wider supply network. Unlike some of their manufacturing partners, LSPs already have a large internationally dispersed footprint of facilities aimed at serving various markets on behalf of their customers. Provided that the right set of capabilities and skills are developed, they can use this global footprint as a foothold to begin to build capabilities around being able to offer a wider variety of services, ultimately enabling the original equipment manufacturers to deliver a new value proposition (configured products closer to customer demand, with the associated benefits of time compression and reduced risk of obsolescence) to their customers. From the LSPs' perspectives, this more complex SC solution provision can increase their bargaining power in the SC and positions them as a more significant service partner in the network. It also leads to higher customer dependence and longer-term contracts, enabling LSPs to protect their core business while also developing new high margin profit streams.

In answer to *Question 1 (How do organisations in the logistics sector execute plans for service growth?)* the changes highlighted above emphasise that, in the new distributed manufacturing SC, the LSP was perceived by both The Shipper and The Customer as better positioned to manage dispersed, final assembly and service activities in the local consumer markets than the original equipment manufacturer itself, who had previously managed a centralised production network. With reference to Table 5, the change implied a shift away from The Shipper, as original equipment manufacturer, managing an in-house globally centralised manufacturing activity, to the network adopting a distributed manufacturing model across nine dispersed locations, with a significant shift in the role performed by LogProd, as captured in Figure 4 below. As such, rather than simply transitioning from products to services, firms can expand their business through the addition of new, and the bundling of existing, logistics services to their portfolio, infusing higher levels of service into their offerings (Kowalkowski et al., 2015). This can be done not just by integrating services downstream into the SC, but also upstream. Here, it is important to note that, even though the overall service transition trend highlighted by Kowalkowski et al. (2015) is just as evident when firms integrate downstream as well as when they do so upstream into the value chain (firms expand increasingly along Trajectory 1 – from products towards process-oriented services and Trajectory 2 – from standardised towards customised services), firms like the one in our study can continue to supply basic, product-oriented services in parallel to the more advanced, process-oriented ones. Furthermore, as Trajectory 3 indicates (from transactional towards relational services), service challenges and opportunities can be linked to expanding from standardised offerings towards advanced solutions.

In relation to Trajectory 3 and in answer to *Question 2 (What is the impact of the new value proposition in terms of developing new capabilities and activities?)* it was further observed that where the production processes were heavily automated or required complex equipment (initial assembly of telecommunication stations), The Shipper preferred traditional centralised manufacturing, which remained in China. However, bespoke analysis of the product-process system and location characteristics revealed an opportunity to develop a distributed system further downstream the value chain (Kumar et al., 2020), leading to a new SC structure and a re-allocation of roles performed by key partners within the network. However, the economic viability of the distributed manufacturing strategy replacing the centralised model was identified as a significant barrier to relinquish the traditional centralised economies-of-scale further upstream the value chain (Kumar et al., 2020). In answer to this, the development of a new service solution facilitated by LogProd integrating further upstream into the value chain enabled them to develop a more lucrative, longer lasting business relationship with The Shipper and The Customer, as they began to develop new capabilities to carry out some additional value-adding tasks along the SC. The new PSS innovation had fundamental consequences for the redesign of the supply network, connected to the offers of the focal company.

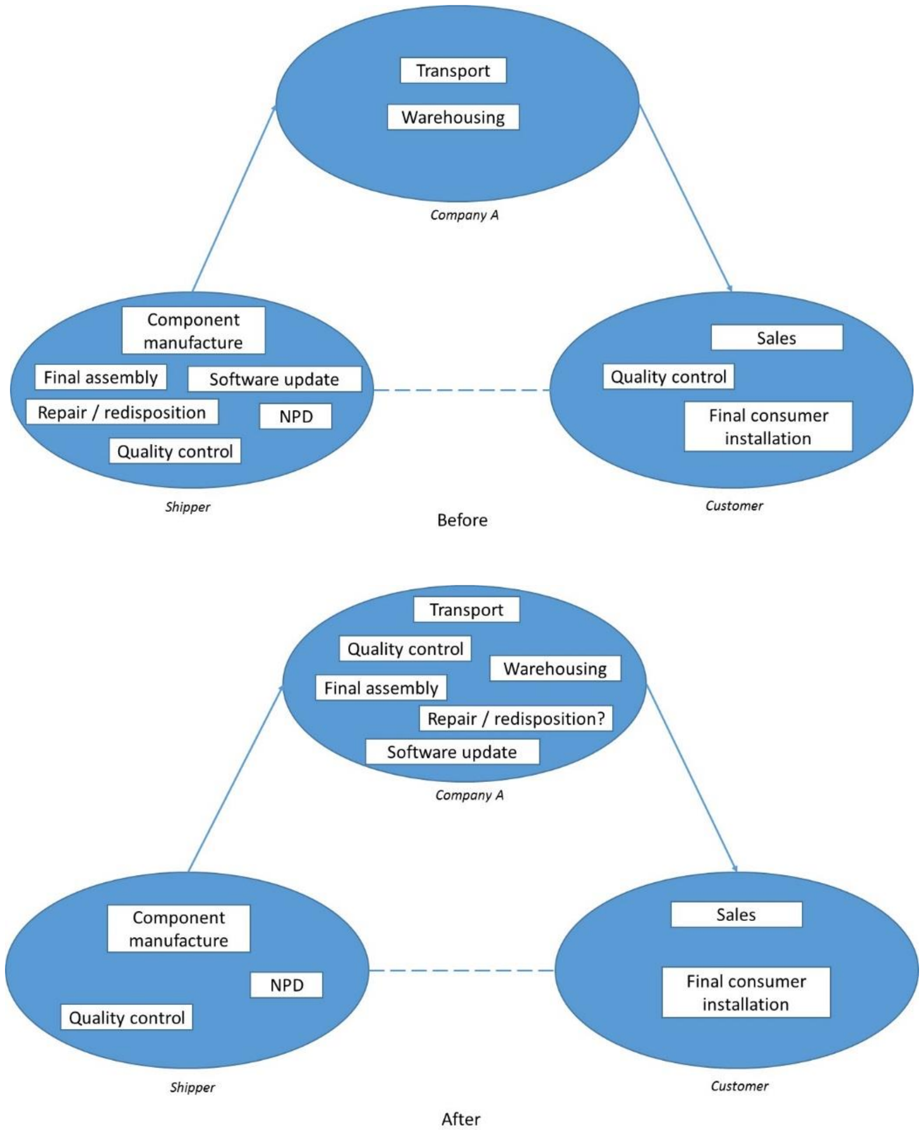

Figure 3. Supply Chain role re-distribution (*Before* and *After* the adoption of the LMS model)

The notion that firms should increase their relational orientation and hence need to develop long-term and close relationships with their customers is inherent in the service transition literature (Pentinnen and Palmer, 2007). However, even when companies already have strong long-term relationships with some of their key partners, system suppliers need to approach their partners at a higher hierarchical level, and frequently with respect to multiple functions and levels, as illustrated in our case study. This reflects that a larger-scale system requires more wide-ranging and strategic customer relationships (and more extensive relationship investments) which allows the solution provider to better anticipate needs and work jointly with its strategic partners (Davies, 2004). Thus, system suppliers have to decide on what relationships they should invest in from a strategic perspective. Such decisions would therefore also have implications for the relative emphasis of the different system supplier roles of the firm within the wider supply network (Kowalkowski et al., 2015), as illustrated in Figure 3.

One of the caveats of the new solution, though, is the fact that as with all servitisation models, as servitisation progresses and the offering becomes more complex for the provider (usually decreasing customer perceived complexity), it covers the activities around the focal capital goods more broadly and spans further over the life cycle of the focal capital goods, typically redistributing roles between the parties involved (Brax and Visintin, 2017). However, this is commonly linked with the popular conceptualisation of servitisation, as the shift of activities downstream in the SC, as opposed to our firm integrating capabilities typically located upstream into the value chain. The design of the supply network and the allocation of roles within it should thus be considered as a critical stage of the solution delivery process. At the same time, regardless of whether the system integrator comes from manufacturing or service roots, each potential provider of integrated solutions must offer a wider range of discrete and bundled offerings than before (Davies, 2006). In essence, system integration is no longer a technical engineering-based task; it is a core strategic business activity that can be offered by companies in the logistics sector to help customers use distributed manufacturing to create value and transform their business.

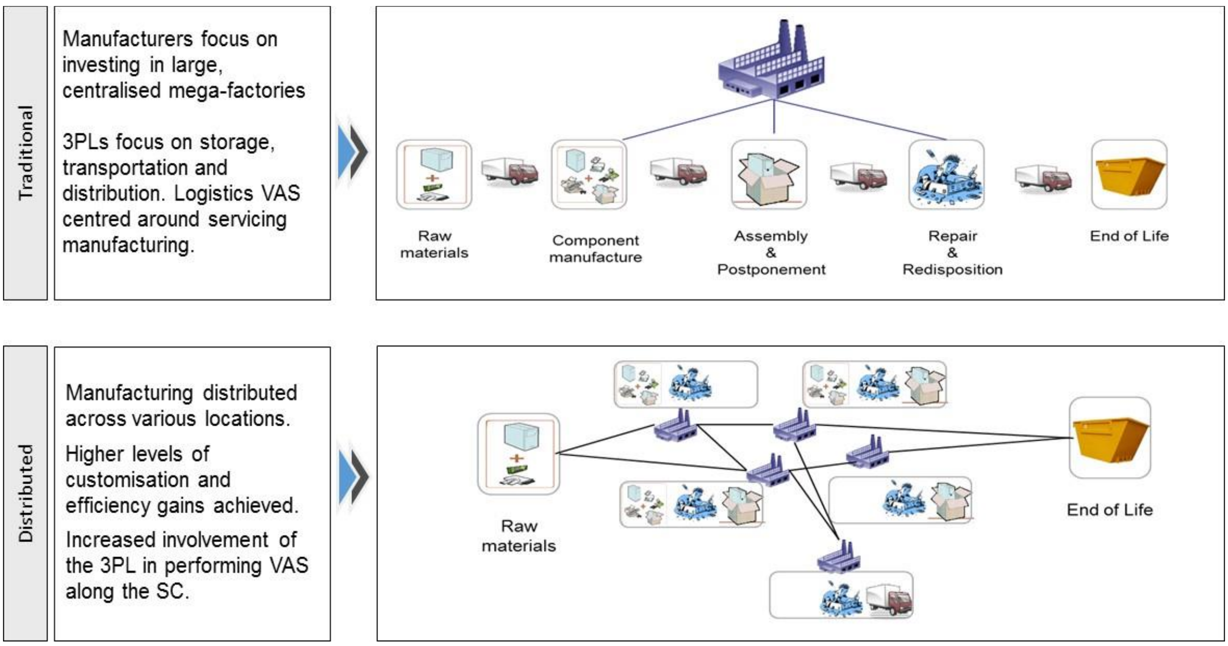

Figure 4. Traditional versus Distributed manufacturing supply chains

The findings of our study also confirm that the concept of distributed manufacturing could provide companies with a competitive advantage in a highly dynamic manufacturing scenario. As well as the final customer being presented with a higher value proposition (reduced lead-times, enhanced personalisation opportunities), we emphasise that distributed manufacturing also provides new opportunities for LSPs to develop advanced PSSs by integrating upstream into the value chain. The newly developed service solution helps bring products closer to the customer and enables customisation and tailor made solutions to a larger extent than the traditional service provision offered in the industry, focused on transportation and warehousing services. The new PSS creates a more personalised experience and increases the perceived added value of the system offering (Kuijken et al., 2017), which is advantageous as advanced customised services tend to lock the customer into a longer-term relationship (Cohen et al., 2006) that cannot be copied by competitors.

As such, our findings are in stark contrast to those of Reim et al. (2016). Their study implied that to offer increased product availability, it is crucial for firms to already have the competencies to provide the necessary services quickly and efficiently. This requires access to service delivery personnel with the appropriate skills and development of service routines and in situations in which such capabilities are absent or limited, PSS operation is not recommended. Yet, our study highlighted that, by taking a SC perspective, PSSs' operation can by successfully managed provided that the required capabilities can be found in the wider network of partners. Thus, by lacking a SC perspective, most of the extant studies mainly focus on fractional parts of PSS innovation (i.e. conceptual design), and they cannot readily assist manufacturers to adjust strategy at a high level and implement sustainable PSS solutions at a low level. By focusing on the implementation of a distributed manufacturing strategy at network level, our research highlights a strategic development of a PSS that could be adopted by other companies operating in a context similar to the one we present (Song et al., 2015).

As the relationship between key SC partners intensifies, we also highlight that the deeper industrial companies venture into PSS the more important it is for the value creation process for each company within the system to also be considered, as well as the value chain as a whole (Matschewsky et al., 2018). However, a number of potential risks should also be highlighted: potential reluctance of shippers to transfer responsibility of manufacturing processes to an LSP, in fear of loss of control and power; reluctance of LSPs to take on additional risk of capital costs and product liability; new technologies making further, radical changes to manufacturing processes and SC set ups that could further threaten the newly adopted model; potential access to large investment and competitive response from manufacturing companies to set up distributed manufacturing networks using own facilities; complexity of re-designing manufacturing and SC processes to move from the traditional set up to the new LMS set up; increase complexity of managing a distributed manufacturing network (compared to managing all manufacturing under one roof).

Highlighting these risks is especially important because providers generally need to assume increased operational risks when delivering PSSs, which represents a key barrier towards their full-scale PSS transformation (Reim et al., 2016). In unknown and turbulent environments, it may be more suitable for other companies to avoid offering a PSS or at least to share the risks across the SC (Reim et al., 2016).

Conclusions

Adopting ‘service growth’ as the main theoretical perspective, our study illustrates how LSPs can escape the commoditisation trap. Distributed manufacturing offers immense opportunities for service growth to become an important source of revenue and profit. We offer insights into how LSPs can transform their business from selling a standardised offering (such as warehousing and transportation) to selling solutions. We focus on the outcome of servitisation, on a solution offering of a LSP that has undergone an organisational process associated with the service-oriented strategic change (Brax and Visintini, 2017) as a result of the adoption of a distributed manufacturing strategy at network level. Beyond increased service business orientation and the addition of services to a firm’s portfolio, service growth also encompasses changes that have profound implications for both the company and its business network.

Furthermore, by examining PSSs from a value-creating perspective, we contribute to existing PSS literature which tends to analyse PSSs and their effectiveness from a business (internal) perspective or a macro (ecological / environmental) perspective (Kuijken et al., 2017), rather than a SC perspective, where we particularly focus on the migration of roles across the network as new service solutions are developed. The consideration of the PSS, seen as a paradigm shift that creates new potential for innovation (Meier et al., 2010) can help to understand the implications of implementing distributed manufacturing, by exploring the resulting network structure, new value proposition and the changing roles and capabilities of players along the SC. This further emphasises the need to adopt a SC perspective when looking to develop innovative PSS solutions. This might challenge some of the current thinking away from interpreting servitisation as a manufacturer / service provider’s change of focus from distributers and integrators to end users (Vandermerwe and Rada, 1988). In studying manufacturers’ downstream transition towards customers, we need to recognise that some service firms in an integrator position are moving upstream towards the product supply.

As such, another theoretical contribution relates to the process organisations can follow to capture a larger share of the value generated within a SC’s value system. Using the adoption of a distributed manufacturing strategy by the OEM, a LSP can appropriate higher customer value by integrating upstream into the value chain. This is a completely different perspective to the majority of the literature in the field, where value appropriation happens by companies integrating downstream into the SC. We demonstrate that the model of servitisation as a forward unidirectional process across the continuum from good-to-service-focused is simplistic. Companies can also move in a reversed direction or move possible back-and-forth, or extend and restrict their position along the servitisation continuum (Davies, 2003; Finne et al., 2013).

In this context, our study emphasises that organisations further upstream the SC (such as OEMs) can fully benefit from the advantages of distributed manufacturing and postponed final product differentiation, without the trade-offs associated with needing to develop and manage new manufacturing facilities closer to each supplied market. By developing key partnerships with actors which are ready to embark on the development of a new PSS (in our case through a LSP incorporating capabilities typically located further upstream the value chain) the manufacturer is able to benefit from a new value proposition without further investment in developing any in-house production capabilities. Intrinsically, with limited asset investment, the shipper and the customer were able to provide, in our case, reduced lead-times, improved inventory accuracy, better quality, improved productivity rates and reduced costs. This, however, increases their reliance on the now higher value adding LSP.

Our study also highlights further potential for improvements and future directions for the LMS model presented, as well as some potential barriers for wider adoption. Before embarking on a journey of redesigning distributed manufacture SCs and re-allocating roles along the value stream, companies should also understand the end-to-end SC costs and the impact of their decisions both upstream and downstream. For example, following the implementation of the LMS model, the LSP experienced a reduced need to use air freight to serve their distributed manufacture customer, which represented one of their main sources of profit. This clear need to understand the cost structure of a new business model represents an area that requires further investigation. For example, with the final assembly and product / software configurations taking place in the newly adopted business model at LogProd's facilities closer to the consumer markets, components have lower risks of obsolescence, thus are now being shipped by sea and / or road. With the final configuration taking place much closer to consumers, the personalised post-assembly products were also delivered by road. As such, it is the higher value adding services (VAS) that now attract higher profits for LogProd, rather than the traditional transportation and warehousing function. Though this change in cost structure was a foreseen and desirable effect for LogProd, it might not be the case for similar players.

Another result of these changes has been an even greater increase in the importance of information management and communication technology and the digitalisation of the SC in coordinating the resulting globally dispersed activities. With the incurring levels of increased complexity, the importance of SC transparency and accurate coordination of activities has never been greater. This can, however, be seen as a further opportunity for the LSPs to develop SC service solutions, benefiting from the current knowledge they already have of managing the material, information and financial flows in the SCs they operate in.

Our study on distributed manufacturing as an enabler for service growth has substantial practical relevance for managers. It offers concrete guidance for managers who seek to increase their competitive advantage over other providers by further integrating into their partners' processes. We also offer managers practical insights into the necessary capabilities they need to develop for this specific pathway. At the same time, as service growth becomes a mainstream strategy, firms may need to rethink who manages the combination of servitisation strategy, product manufacture and service process delivery. One such possibility is to enhance the role of LSPs in the supply network which, due to their proximity to the final customer, are key in integrating knowledge into service solutions. A servitisation approach may thus entail a strategic repositioning of firms within the value system. Indeed, servitisation may result in LSPs capturing a larger share of value generated in the industry's value system.

A major limitation of this study is that it is based on a single exploratory case. Though this was deemed as highly appropriate due to the novelty of the concept under investigation and the revelatory nature of the case, we do not claim for generalizability of our results. Future research, adopting a multi-case study design is needed. Further research should also consider exploring the concept across wider supply networks and begin to investigate aspects such as the total cost of the newly emerging distributed SCs and their potential for long term sustainability. Other research methodologies, like surveys and framework validation techniques, could also be implemented to further validate the findings and conclusions of this study.

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