

Lahy, A., Li, A. Q., Found, P., Syntetos, A., Wilson, M. and Ayiomamitou, N. (tbc)
'Developing a Product Service System through a Productisation Strategy: A case from the
3PL industry', *International Journal of Production Research*, pp. tbc. doi: tbc

This is an Accepted Manuscript of an article published by Taylor & Francis in
International Journal of Production Research on tbc, available online: tbc

Developing a Product-Service System through a Productisation Strategy: A Case from the 3PL Industry

Andrew Lahy^{a,b,*}, Ai Qiang Li^c, Pauline Found^e, Aris Syntetos^{b,d}, Mike Wilson^{a,b}, Nicole Ayiomamitou^{a,b}

^a *Logistics Manufacturing Services, Panalpina World Transport Ltd, Basel, Switzerland*

^b *Panalpina Centre for Manufacturing and Logistics Research, Cardiff University, Cardiff, UK*

^c *Buckingham Business School, The University of Buckingham, Buckingham, UK*

^d *Logistics & Operations Management, Cardiff Business School, Cardiff University, Cardiff, UK*

*Corresponding author: andylahy@gmail.com

Developing a Product-Service System through a Productisation Strategy: A Case from the 3PL Industry

A Product-Service System (PSS) is created by combining a tangible product and an intangible service into one integrated offering. Thus, a PSS can be achieved by a production company adding intangible services to a product using a servitization strategy. Or, by a service company adding a tangible product to a service by means of a productisation strategy. The focus of this paper is on the latter. Our work demonstrates a significant gap in the literature in this area. To address this, we adapt an existing PSS conceptual framework provided by Oliva and Kallenberg (2003) as a means to identify the driving and restraining forces considered by a service company as it explored the possibility of pursuing a PSS productisation strategy. The conceptual framework is applied in an exploratory case study with a 3PL service provider. Application of the framework reveals new driving and restraining forces not previously discussed in the literature. Furthermore, it allows a preliminary quantification of the driving and restraining forces using a force field analysis approach (Lewin, 1951). Our work contributes towards the expansion of the empirical knowledge base in the area of PSS.

Keywords: Supply Chain Management, Product Service Systems, Logistics, Productisation, 3PL

1. Introduction

The commercial attractiveness of PSS is particularly relevant for manufacturing companies, as adding a service component to their production offering has been found to bring more sustainable competitive advantages (Kandampully, 2002) and higher margins (Liu et al. 2014; Mont, 2002a). Case studies on Xerox (Rothenberg, 2007; White et al. 1999), IBM (White et al. 1999) and Rolls Royce (Baines et al. 2007; Spring and Araujo, 2009) have demonstrated the financial benefits of integrating services with a production offering through a strategy of servitization. However, despite the apparent commercial attractiveness of such strategies, [Gebauer et al. \(2005\)](#) point out that [many](#) organisations struggle to successfully implement them [\(Coreynen et al. 2017\)](#), a problem [the authors define referred to](#) as the “service paradox” [\(Gebauer et al. 2005\)](#).

As the aforementioned research illustrates, most PSS research to date has focused on production companies adding services to create a PSS. Evans et al. (2007) go as far as to argue that production companies should be at the heart of any PSS.

However, illustrated using Tukker’s PSS framework (Figure 1), [PSS](#) can be achieved either through a servitisation strategy (adding services to a production offering) or a productisation strategy (adding tangible products to a service offering). This highlights that PSS is achievable for both production and service companies.

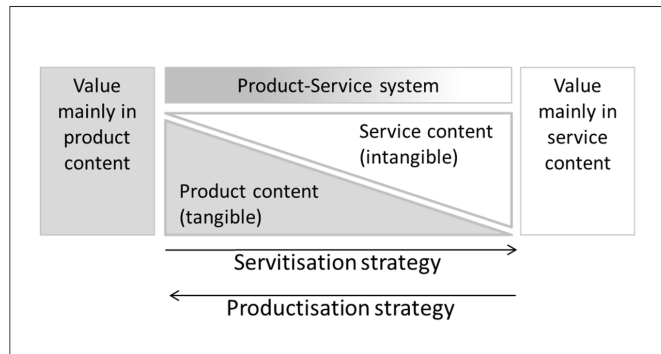


Figure 1: Productisation vs. servitisation strategy (adapted from Tukker, 2004)

To date however, there has been very little work on productisation strategies (Harkonen et al. 2015; Leoni, 2015) and case learning of productisation is not well documented (Chattopadhyay, 2012). Moreover, most literature related to productisation is found among business practitioner magazines and not discussed explicitly in the academic literature (Harkonen et al. 2015). It is this gap in the academic literature that motivated this research, leading us to specifically address the topic of PSS productisation strategies in this paper.

Such research is timely, as examples exist of service companies adding tangible products to create a commercially viable PSS. Consider Amazon's success in developing a PSS by starting with a service offering (web shop) and then adding a physical product (Kindle), or Google's attempt to develop self-driving cars and mobile phones. In addition to these two industry cases, there are growing calls in the literature for more practical examples of, and empirical research related to, productisation strategies (Harkonen et al. 2015; Leoni, 2015).

Specifically this paper addresses the following research question:

- What are the relevant driving and restraining forces for a service company to add physical products to their offering to create a PSS?

The terms driving and restraining forces are deliberately selected to make use of the terminology of force field theory (Burnes and Cooke, 2013; Lewin, 1951; Swanson and Creed, 2014). These terms are discussed in more detail in later sections.

To address the aforementioned research question, the remainder of this paper is structured into six sections. The next section provides details on the research methodology used. Section 3 contains the results of a literature review carried out to bring together existing knowledge related to the research question. Section 4 provides the empirical findings generated from an exploratory case study. The overall conclusions drawn from the research are provided in section 5, with the research limitations acknowledged in section 6. We conclude with section 7, which provides avenues for further research in the area of PSS productisation.

2. Methodology

In this section we explain the overarching methodology used in this paper. Separate sub-sections provide details on the method used to select and review existing literature, to develop the conceptual framework and to collect data in the case company, hereafter referred to as the CasComp.

The overall methodology applied in this paper is pictorially presented in Figure 2. The boxes in the figure provide the steps applied, with each one expanded upon in the following sub-sections.

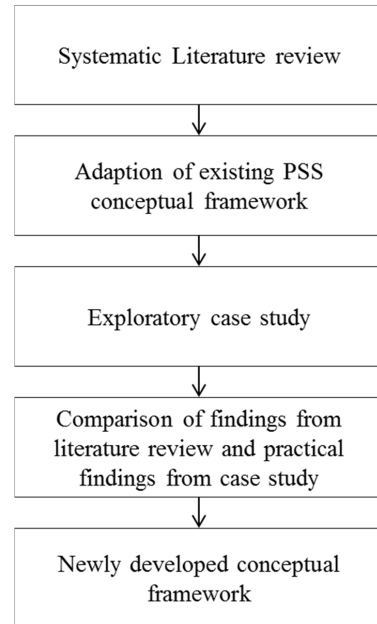


Figure 2: Overview of methodology

2.1 Literature Review

To ensure we collected a broad view of the existing literature, we searched the term “PSS” and “Product-Service System” (in titles, keywords and abstracts) in three separate search engines: *Google Scholar*, *Research Gate* and *EBSCO Discovery Service (EDS)*. We selected *Google Scholar*, as this would give us the broadest net of papers to research the key terms. We used *Research Gate* as it contains a large number of conference papers and would ensure we captured the most recent thinking on the subject. And finally we used *EDS* as a way to identify high quality, peer reviewed papers. Only papers that included at least one of the aforementioned search terms was included in our research.

This initial search generated a large number of results. To reduce the number of papers, the additional keywords “productisation” and “productization” were first added

to the search criteria to identify papers on these specific topics. This generated only a small number of papers. Next, we expanded the search, and looking at both production and service companies, we aimed to identify papers related to the driving and restraining forces towards pursuing a PSS strategy. We identified that a large number of related terms were used to describe these forces, examples included the terms motivations, enablers, challenges, obstacles and drivers. Thus, each of these terms was individually added to the keyword search criteria to identify associated literature.

From this search strategy, more than 180 papers were identified. These papers were reviewed and discussed by the research team and from this, a total of 90 papers were selected for inclusion based on their relevance to the research question. From these 90 papers, we also searched for conceptual frameworks that could be applied in our research.

As indicated in Table 1, the literature review included papers from a range of journals and conference proceedings. A full list of the papers analysed can be provided on request.

Table 1 : Source of papers used in systematic literature review

Source (Journal, conference paper, book, report)	No. of Papers
Business Process Management Journal	1
Business Strategy and the Environment	1
CIRP Journal of Manufacturing Science and Technology	1
Computers & Industrial Engineering	1
International Journal of Advanced Manufacturing Technology	3
International Journal of Business Administration	1
International Journal of Innovation Management	1
International Journal of Operations & Production Management	2
International Journal of Production Research	14
Journal of Cleaner Production	13
Journal of Engineering Design	1
Journal of Engineering and Manufacturing	1
Journal of Manufacturing Technology Management	3
Product: Management & Development	1
Supply Chain Management	1
The Journal of Sustainable Product Design	1
The Service Industries Journal	2
Conference paper (various conferences)	27
Books / reports / thesis / working papers	15
Total Papers analyzed	90

The papers were read and catalogued, based on whether they were focused on productisation, servitisation, or both. Then, text analysis on the keywords provided by the authors of the papers was carried out as a way to verify our analysis and conclusions. The text analysis was carried out using an on-line text analysis tool <https://www.online-utility.org/text/analyzer.jsp>

2.2 The Conceptual Framework

The literature review was also used to identify conceptual frameworks that could be employed as a lens to structure this research. We opted to use the conceptual framework created by Oliva and Kallenberg (2003). Although used by the authors to investigate the transition of a production company to a PSS, the framework was found to be a useful means to understand the journey that an organisation of any type could take towards

developing a PSS. We elected to make use of this conceptual framework and adapt it for our purposes rather than create something new, as we felt that using an existing conceptual framework would facilitate later research to compare the respective journeys taken by production and service companies.

The adjustments to the framework were made based on the knowledge acquired from the literature review and from the research with the CasComp. However, we have elected to introduce the framework and the changes made to it here, as the framework is key to understanding the remaining parts of the paper.

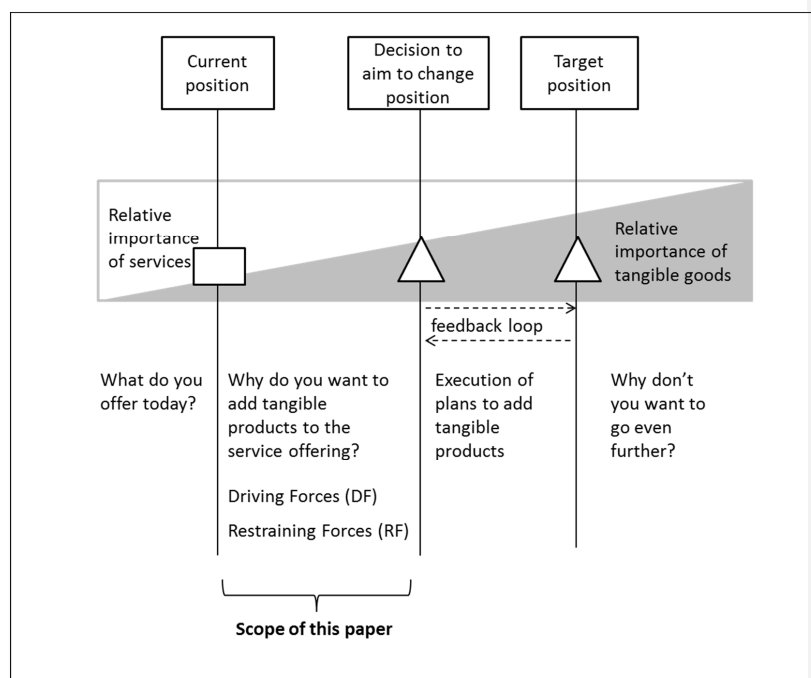


Figure 3: Conceptual framework to understand the journey of a service company to a PSS. Adapted from Oliva and Kallenberg (2003)

We make four major adjustments to the original framework by Oliva and Kallenberg (2003). First, as we are focused on the PSS productisation journey, we

changed the focus of the framework to reflect the transition from adding intangible services to adding tangible goods. Second, we added an additional step into the framework, which we labelled as “decision to aim to change position”. This allowed us to create a clear line to distinguish the period before the company decided to pursue a PSS and the period after the decision was made. We did this, as we found it was useful to make a distinction between the factors considered when deciding to pursue a PSS and the factors encountered after the decision is made. The former factors paint a clearer picture as to “why” a company may want to pursue a PSS strategy, and the latter factors relate to “how” the decision is implemented. This is in line with the ideas of Cook et al. (2012) and Gebauer et al. (2005) who make a distinction between the disposition or willingness to pursue a PSS and the ability and capability to do it.

Making the distinction between the decision making and the execution phase also facilitated the application of field theory (Lewin, 1951). This use of field theory opened up the possibility of being able to quantify the driving and restraining forces and begin to make sense of their relative strengths.

The third change we made to the framework is the addition of the terms driving forces (DF) and restraining forces (RF). As previously noted, we identified that a number of labels are used to explain these different factors, including terms such as motivations, triggers, opportunities, obstacles, challenges and critical success factors (Baines et al. 2009; Battaglia et al. 2016; Belvedere et al. 2013; Cherubini et al. 2015; Isaksson et al. 2009; Oliva and Kallenberg, 2003; Pereira et al. 2013). In our framework, we deliberately apply the different terms to make a clear distinction between, on one hand, the forces influencing the strategic decision to pursue a PSS and, on the other, the factors influencing the implementation once the decision has been made. For clarity, we use the following definitions in our framework.

- Driving Force (DF): Any force which positively leads the company to decide to pursue a PSS.
- Restraining Force (RF): Any force which dissuades the company from deciding to pursue a PSS.

The last change we made to the framework is the addition of a feedback loop between the decision and target setting stage. We do so to demonstrate that the strength of the driving forces relative to the restraining forces will influence how far the company aims for in terms of their target position. In addition, the feedback loop demonstrates that the factors encountered during the execution phase may result in the company going back and making different strategic decisions, either expanding the use of PSS or equally, deciding to reverse the decision to pursue a PSS.

We elected to focus only on the driving and restraining forces in our case study and deliberately excluded collecting data on the factors encountered during the implementation phase. This is to provide a clearer focus for our research.

We used this adapted conceptual framework as a research lens to explore, by means of a case study research method, the actual driving and restraining forces for a service company pursuing a PSS productisation strategy.

2.3 Case Selection and Data Collection Design

The CasComp was selected as when this research was initiated, the company was in the process of considering a PSS productisation strategy. Thus, the possibility arose to observe and identify the practical driving and restraining forces considered by a service company assessing this strategy. An exploratory, qualitative, case study was used in line with the arguments put forward by Yin (2009), who suggests the use of this approach when attempting to address questions exploring what is occurring and why. In our case,

the focus was on understanding why a service company would consider a PSS productisation strategy and what were the relevant driving and restraining forces influencing that decision.

Our research with the case company began in January 2012 and ended in December 2016. Participant observation was the predominant data collection method throughout the research. The data collection techniques proposed by DeWalt and DeWalt (2011) allowed us to gather first hand data from the managers as they discussed the productisation topic in their natural, working environment (Gamst, 1980). However, relying on only one data collection method opened up the possibility for research bias. Consequently, to allow triangulation of the data (Denzin, 1978), secondary data, both internal and publically available, was also analysed and a small number of interviews were carried out with the senior management team to ensure the data collected in the participant observation sessions had been correctly interpreted.

For the participant observation data collection, members of the research team participated in four annual strategic review sessions at the company, which were attended by the Chief Executive Officer, Chief Financial Officer, Chief Legal Officer and other senior members of the management team. One researcher also attended quarterly strategic review meetings (16 in total) which included many of the CasComp senior management team. In addition to the formal quarterly reviews, 15 informal interviews and 10 smaller workshops (2 of which included CasComp customers) were carried out with senior managers in CasComp to delve into more detail on specific ideas. At all of these events, detailed notes were taken and summarised back to the CasComp for verification. Secondary data collection was also carried out to look for inconsistencies with data collected from the managers. Secondary data collection included a review of the company's published annual reports, the company's internal

and external website, and internally available meeting minutes and CasComp created presentations.

To check the validity of the research method, which relied heavily on qualitative data collection, the criteria proposed by Zachariadis et al. (2013) was applied to verify that the research methodology met the criteria for design validity, analytical validity and inferential validity. The research limitations identified are provided in a later section of this paper.

With the CasComp data collected, the final step in our methodology involved populating the conceptual framework with the findings generated from CasComp. To do this, a framework from the Mindtools toolbox (Mindtools, accessed 15 June 2017) and an approach proposed by Ramalingam (2006) were used. Using this involved the research team and the CasComp management jointly listing all of the forces in support of the change (the driving forces) in one column, and listing all the forces against the change (the restraining forces) in another. The research team then worked with the CasComp to quantify the strength of each force from one to four, applying positive numbers to the driving forces and negative numbers to the restraining force. The choice of the numbers 1 to 4 was selected by the research team after consultation with the CasComp on the most appropriate representation of the strength of the forces. For example, a driving force that was discussed by the CasComp, but not in great depth, was given a weighting of 1. Conversely, a driving force discussed in great depth and which had a major influence on the decision was given a weighting of 4. The same principle was applied to restraining factors but using a negative scale of -1 to -4. This method allowed us to quantify the strength of each driving and restraining force, and by using positive and negative numbers respectively, to calculate an overall net effect of the two opposing forces.

Field Code Changed

This overall methodology allowed us to address the research question specified in the introductory section of this paper and draw conclusions from our research.

3. Findings from literature review

3.1 Productisation and PSS

As per the literature review procedure laid out in section 2.1, the initial focus was to bring together current research on PSS and productisation. ~~The~~ literature reviews on PSS by Baines et al. (2007) and Beuren et al. (2013) ~~and Mahut et al. (2017)~~ provide a good general overview of the many research streams considered in the field of PSS. Of the ~~two~~three, ~~only~~ Beuren et al. (2013) ~~and Mahut et al. (2017)~~ identify productisation as a stream of literature within PSS, but ~~the authors~~ neither discuss productisation in detail, nor provide a ~~clear~~ definition of what is meant by ~~the term~~ productisation ~~in their research~~. This lack of definition is important. As pointed out by Harkonen et al. (2015), the term productisation is not fully established or defined in the scientific literature even though it is regularly used by practitioners and industrial managers. Although Harkonen et al. (2015) provide more than 30 different explanations of the term productisation, many are related to standardising service offerings, or bundling software and hence not appropriate in the PSS context. Using the widely recognised definitions of PSS provided by Goedkoop et al. (1999), productisation in the context of PSS relates to adding a tangible product to an existing intangible service offering.

When considering productisation in this sense and within the context of PSS, the literature review identified very little existing research. In fact, of the 90 papers reviewed, only one conference paper was identified that had a predominant focus on achieving a PSS through productisation: Leoni (2015). Leoni (2015) encapsulates the current stage of productisation research:

“The productisation concept is still not well established within academic discussion, so much so that it is not possible to identify a specific research community dealing with this topic. More productisation-specific studies are needed and significant work remains to be undertaken.” (Leoni, 2015, p. 13)

This lack of specific research on productisation in PSS contrasts with the large number of PSS papers specifically focused on servitisation, of which 46 were found (51% of papers). The remaining 43 papers (48%) did not specify a focus on either on productisation or servitisation.

This lack of focus on productisation was also confirmed using our keyword analysis, where the keyword “servitisation” was found to be the sixth most common keyword used, whereas the keyword “productisation” did not appear at all. The results of the keyword analysis are provided in Table 2

Table 2: Results of keywords analysis on selected PSS papers

Order	Key word	Occurrences	%
1	Service (s)	82	10.1%
2	Product (s)	62	7.6%
3	System (s)	60	7.4%
4	PSS	27	3.3%
5	Model	16	2.0%
6	Servitization	15	1.8%
7	Innovation	14	1.7%
8	Manufacturing	13	1.6%
9	Management	13	1.6%
10	Business	12	1.5%
Total number of key words analyzed		811	
Unique words analyzed		290	

We conclude from this analysis that there is a significant gap in existing literature on the exploration of the phenomenon of PSS productisation. To begin to explore the topic, we propose that the logical place to start is to understand if and why a service company would consider a strategy of PSS productisation. To answer this, we move onto the second part of our literature review. In this, we looked more broadly at the identified driving and restraining forces for any company (either a service or a production company) to pursue a PSS.

3.2 Driving and restraining forces towards a PSS

A number of authors provide comprehensive lists of the driving and restraining forces considered when a company considers pursuing a PSS ([Kuo et al., 2010](#); [Lockett et al., 2011](#); [Matschewsky et al., 2017](#); [Oliva and Kallenberg, 2003](#); [Pessôa and Becker,](#)

Field Code Changed

[2017](#))([Kuo et al., 2010](#); [Lockett et al., 2011](#); [Oliva and Kallenberg, 2003](#); [Pessôa and Becker, 2017](#)). However, most focus on either the driving or restraining forces, and do not consider both in parallel (for an exception see Mont, 2002a). In the following sections, we bring together existing literature on the driving and restraining forces of pursuing a PSS, and also consider if the research identified these forces from a production or service provider perspective, or both. We created a list of the different forces already identified in the literature and the perspective from which they were identified, and provide an extract of this list in [Table 3](#)~~Table 3~~. The full list contained over seventy items and thus is not provided in its entirety in this paper; the full list can be provided on request.

Formatted: Font: Not Bold

Table 3 : Driving and restraining forces identified in literature

Driving forces for adopting a PSS	Force identified specifically for				Source
	P/C	S/C	Both	N/S*	
Opportunity to customise offers and delivery of the offer to customers			×		Goedkoop et al. (1999)
New revenue opportunities (e.g financing, refurbishing or upgrading)	×				Mont (2002), Lockett et al. (2011)
Improves relations with consumers due to increased customer contact and flow of information about consumers preferences	×				Mont (2002), Penttinen and Palmer (2007)
Services offer a more sustainable competitive advantage, as they are less visible and more labor dependent and therefore more difficult to imitate	×				Oliva and Kallenburg (2003), Lockett et al. (2011)
Better services sell more products	×				Oliva and Kallenburg (2003)
Restraining forces towards adopting a PSS					
Complexity to develop due to required involvement of multiple stakeholders				×	Mont (2002)
Infrastructure needs to be found or developed to support PSS				×	Mont (2002)
Lack of support from relevant laws and regulations	×				Kuo et al. (2010)
Lack of market acceptance	×				Kuo et al. (2010)
Underlying performance measures of PSS are not obvious and difficult to quantify.				×	Phumbua and Tjahjono, (2012)

*P/C: Production Companies; S/C: Service Companies; N/S: not specified

To expand on the extracts provided in the table, the next sections provide additional details of the main driving and restraining forces identified in the literature.

3.3 Driving forces

The initial PSS concept, developed by Goedkoop et al. (1999) was applied to both production and service companies; it was proposed that the adoption of PSS solutions was driven by commercial and environmental objectives, with PSS helping to improve both. Mont (2000), focusing only on production companies, proposed that commercial objectives (pursued as eco-objectives mainly to reduce costs) were more relevant driving forces for companies to improve the environment and generate profits in parallel. This idealistic win-win principle (Cook et al. 2006) however may not always be achievable (Tukker and Tischner, 2006) and this leads to the question of whether a company would be driven to pursue a PSS for solely environmental reasons or solely commercial reasons, or whether a company would only pursue a PSS strategy if it helped to achieve both. Despite the early focus on the environmental motivations of PSS (Goedkoop et al. 1999; Maxwell et al. 2006) [and its continued link to environmental concerns \(Rondini et al. 2017\)](#), the literature review suggests that commercial motivations are now the predominant reason for firms to pursue a PSS (Aurich et al, 2009; Resta et al. 2015)

Our research found that many authors explore in detail the forces driving companies towards pursuing a PSS. Overall, we identified a total of 35 driving forces for a company to pursue a PSS, but with nearly all considering PSS from a production company perspective. [For example, Shen et al. \(2017\) propose that manufacturers are attracted to PSS as it offers a means to lock customers into long-term relationships, increase the useful life of products and to generate higher revenues.](#)

Oliva and Kallenberg (2003) identify a number of driving forces that may lead a production company to decide to pursue a PSS strategy. These include electing to

Formatted: Indent: First line: 1.27 cm

pursue a PSS to reduce customer complaints, to improve efficiency, quality or delivery time, to increase revenue or profit margins or to respond to a management change or new customer request. These authors focus ~~mainly~~^{only} on the commercial motivations with limited mention of environmental motivations.

Similarly Lockett et al. (2011) do not consider any environmental motivations for pursuing a PSS, and suggest that the drivers for developing a PSS can be grouped into three types: i) revenue enhancing motivations, ii) value enhancing motivations, or iii) motivations related to developing a sustainable competitive advantage (for example, locking in a customer, or developing capabilities that are difficult for competitors to replicate). The authors also point out external factors such as the availability of new technologies or access to new information as forces that may encourage a company to pursue a PSS.

Pereira et al. (2013) provided the most comprehensive overview of the motivations of pursuing a PSS, identifying 33 different forces that could motivate a firm to pursue a PSS, but all are considered from a production company perspective.

Of all the papers, only Mont (2002a) was found to consider the driving forces of PSS from the perspective of a service company, and only 4 possible driving forces are noted, namely PSS:

- Offers an opportunity to extend and diversify;
- Protects market share by bringing in a tangible component that is not so easy to copy;
- Facilitates communication (as it is easier to convey information about a tangible product than a service);
- Ensures a certain level of quality that is easier to maintain (product quality).

Beyond the work of Mont (2002a), considering the driving forces from a service perspective is largely overlooked.

3.4 Restraining forces

Our review identified 37 restraining forces to pursuing a PSS, but found no examples of research investigating the specific restraining forces from the perspective of a service provider. From the 37 identified restraining forces, we identified two interesting groups. Firstly, there are those forces that are not specific to either production or service companies and can logically be assumed to be relevant for both. Secondly, and for this paper most interestingly, there are those factors that may be a restraining force for a production company, but not for a service company. These could be potential sources of competitive advantage for service companies over production companies when developing a PSS.

In the first group, [research by Matschewsky et al. \(2017\) provides a comprehensive list of 34 restraining forces \(the authors use the term challenges\), many of which could apply to both production and service companies, but the authors go on to focus on specific challenges for production companies.](#)

Formatted: Justified, Indent: First line: 1.27 cm, Space Before: 12 pt

[More specifically,](#) Mont (2002b) points out restraining forces such as conflicts of interest between different actors and the customers' lack of knowledge about cost structures. Long et al. (2013) focus on the difficulty of understanding customer requirements and Song et al. (2013) highlight the difficulty of prioritising the requirements. Leseure et al. (2010), Lockett et al. (2011), Nudurupati et al. (2013) and White et al. (1999b) indicate that relationships and alignment of incentives are a major barrier, both in terms of alignment across organisations, but also within organisations, particularly in terms of accounting methods and bonus measurement. Oliva and

Formatted: Font: (Default) Times New Roman

Kallenberg (2003) highlight the major managerial challenges such as implementing new organizational principles, structures, processes, capabilities, metrics and incentives. Barquet et al. (2013) identify availability of financing as a major restraining force for PSS and Lockett et al. (2011) stress the fear of intellectual property rights leakage. Although all of these restraining forces were identified from research into production companies, all could be equally applicable to service companies, thus could be considered more as general organisational forces, rather than being specific to production companies.

In the second group (factors that are a restraining force for production companies but not necessarily for service companies), Oliva and Kallenberg (2003) note the complexity of changing from transactional to relationship based service provision. This is an obstacle for production companies, but often a source of advantage for service companies.

It is also worthy of note that, with the exception of Kuo et al. (2010) who do look to apply a quantitative binary analysis to the barriers of PSS, most research to date is limited to qualitative lists. Limited research was identified that looked to apply quantified metrics to measure the strength of the driving and restraining forces.

3.5 Conclusions from literature review

The first part of the literature review conclusively demonstrates the lack of research on PSS productisation strategies to date. Rather than a gap, the second part of our literature identified that there is an abundance of research on the driving forces and restraining forces for companies to elect to pursue a PSS. However, the findings from the literature review do suggest that the factors are predominantly considered from the perspective of a production company, and the perspective of the service company is

largely overlooked. Moreover, the literature review identified such a large number of factors as either driving or restraining, that this re-enforces our view that these many factors should be brought into a clearer conceptual framework so that they can be further defined and explored. We also conclude that most research to date has provided qualitative lists of the driving and restraining forces and that there is a lack of understanding into the relative strength of the different forces. We aim to address these gaps with the findings from our case study which is detailed in the following section.

4. Case study findings

This section is divided into four sub-sections. The first provides a brief introduction to the CasComp. The second and third sub-section provide the main findings from the exploratory research with the CasComp, with the second sub-section focusing on the driving forces and the third on the restraining forces considered by the company when assessing the possibility of pursuing a PSS. Finally, section four brings the findings together into the conceptual framework introduced in earlier sections of this paper.

4.1 Introduction to the CasComp

CasComp has a long history of providing air freight and ocean freight brokerage services and in 2011 added logistics services to its portfolio. As such, at the start of this research, the company was a pure service provider and had no production capabilities. The company is a global organisation, with over 15,000 employees in more than 200 countries.

Between 2012 and 2016, CasComp pursued a strategy of productisation, adding four new manufacturing operations to their global portfolio. The findings presented here are based on this 4 year period and the company's move towards a PSS productisation

strategy in this period.

Before providing the details of the identified forces we provide an introductory note to the CasComp's wider approach to strategy formation. The approach the CasComp uses can best be described as emergent (Mintzberg and Waters, 1985) and opportunistic (Isenberg, 1987) whereby multiple decisions are made over a long period of time and are often adjusted as new ideas or opportunities arise. The following sub-sections then do not just list the driving and restraining forces considered, but also the methods and journey the CasComp took to identify them.

4.2 Driving forces for considering a strategy of productisation

In 2012, CasComp carried out a wide strategic review to identify the risks and opportunities for the company going forward. The initial driving force for considering a PSS was to explore new options outside of the company's core industry, due to the expected long-term commoditisation of their existing service offering. This commoditisation restricted the company's ability to grow margins in the short term. In the long term, the company expected that new technologies were likely to bring further automation and standardisation to their core industry, and hence it was expected that margins in their core service industry would continue to decline. Initially then, the driving force to consider a PSS was to identify higher margin business opportunities outside of the company's existing core business.

The company initially focused their research on the electronics and technology market, as CasComp had a background of providing logistics services in that market. The company started with a high level, macro, overview of an electronics supply chain, provided in Figure 4.

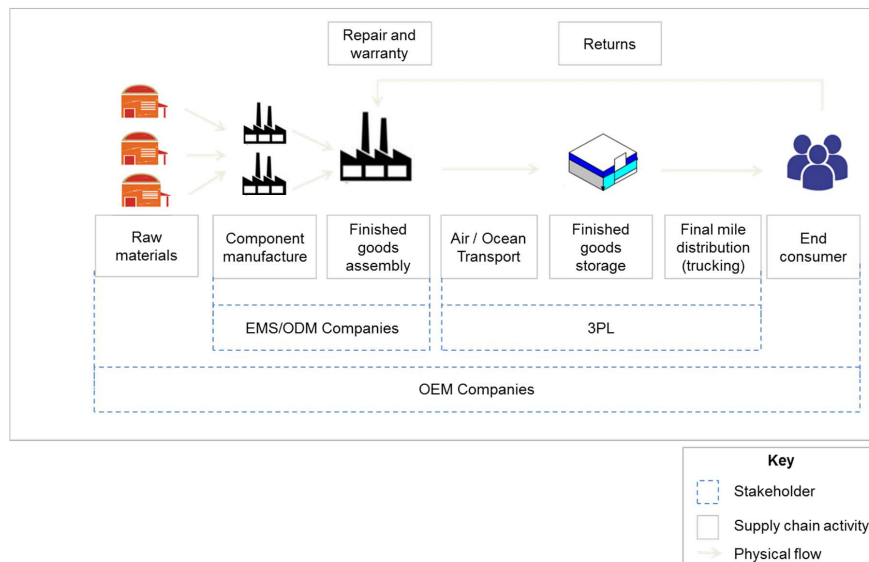


Figure 4: Macro view of key steps in electronics supply chain

From the above, the CasComp identified three key stakeholders in the typical electronics supply chain:

- The OEM (Original Equipment Manufacturer) companies. This includes companies such as Dell, HP, and Sony.
- The EMS/ODM (Electronics Manufacturing Service / Original Design Manufacturer) companies. This includes companies such as Flextronics, Celestica, and Jabil.
- The 3PL (3rd Party Logistics Providers) companies. This includes companies such as DHL, Panalpina, K&N and CasComp itself.

Referring back to Tukker's PSS model and the above supply chain diagram, EMS/ODM companies provide the production element of the PSS, the 3PL companies provide the service element (in this case delivering the product), and the OEM

companies provide co-ordination across both elements, and come closest to providing a PSS.

The CasComp further analysed the reported financial results of the different stakeholders in the supply chain, and used www.investing.com to compare the CasComp's twelve month operating margin with the reported operating margin of three EMS/ODM companies (Flextronics, Jabil and Celestica) and two OEM companies (HP and Sony). The CasComp found that the margins achieved by the OEM and the EMS/ODM companies were considerably higher than those achieved by CasComp. This analysis was used by the CasComp to demonstrate the potential for generating higher margins by playing a different role in the supply chain.

As well as the driving force to proactively pursue a productisation strategy, the CasComp also recognised the risk that EMS/ODM companies could pursue a servitisation strategy and add logistics services to complement their own production offering. Thus, the driving force to pursue a PSS was not just to increase margins, but also to pre-empt a possible entry of a production company into the CasComp's service sector.

To compare the potential for the CasComp to add production to their offering with the potential of a typical EMS/ODM company to add logistics services to theirs, the CasComp compared the capabilities required to offer a PSS, and carried out a gap analysis from the perspective of the CasComp and a typical EMS/ODM company. The capabilities compared were reviewed and selected by the CasComp senior management team and based on the CasComp's perceived competitive strengths as a 3PL and the management team's perception of the competitive advantages of a typical EMS/ODM company. The CasComp analysis is summarised in Figure 5.

	Global 3PLs	EMS/ODM Providers	Conclusion
Global Logistics footprint	■	□	<ul style="list-style-type: none"> OEM's currently use EMS/ODM providers AND 3PL's as neither one can provide a combined PSS offering OEM benefits from using one provider for logistics and manufacturing. <ul style="list-style-type: none"> Reduced cost (combined resource / space) Less transportation Less inventory Less complexity Shorter lead times CasComp is well placed to differentiate by offering a combined Logistics and Manufacturing Service
Manufacturing skills	□	■	
Transport network	■	□	
I.T Solution	□	□	
Customer base	■	■	
Proven model (case study)	□	■	
Correct Organisational Design	□	□	
Traditional Logistics systems (WMS)	■	□	
Quality Management Systems for LMS	□	■	
"Real" Lean Capabilities	□	■	
	■	□	<div>In place</div> <div>Not in place (gap)</div>

Figure 5: Gap analysis for production companies (EMS/ODM providers) and service providers (global 3PL's) to provide a PSS

CasComp concluded from the above that although there were more gaps for the 3PL's to add production capabilities (6 gaps for the 3PL's, compared to 5 gaps for the EMS/ODM providers), the gaps that needed to be filled by the 3PL could be closed faster than the gaps needed to be closed by the EMS/ODM. In particular, CasComp concluded that it would take a considerable time for the EMS/ODM companies to create a global logistics footprint due to the complexity of setting up new organisations, tax structures and operating licences around the world.

Thus, contrary to the findings in the literature review, which makes an assumption that a production company is best positioned to add services to develop a PSS, CasComp argued that in their view, the service company (in this case CasComp) was better positioned to offer the PSS than production companies due to two principle reasons. First, PSS requires a close relationship with the customer (Baines et al. 2009)

and most service companies work physically closer to the customer than production companies (Holmström and Partanen, 2014). Second, service companies are more adept and experienced at creating functional delivery type contracts linked to service levels and extended time periods (Reim et al. 2015), compared to manufacturing companies that are more used to transactional type contracts.

A further driving force for the CasComp to consider a PSS was related to innovation and power in the supply chain. The CasComp discussed how the electronics industry had developed over the last 50 years. From this, they concluded that the electronics industry had been traditionally driven by the OEM's, quickly followed by the EMS/ODM companies, and that 3PL's were generally laggards in the industry, who re-actively responded to the strategic changes of the OEM and EMS/ODM companies. In other words, the industry was led by those companies involved in the design and manufacture of products, and those companies providing logistics services were locked into a cycle of responding to the changes initiated by the production companies. From this, the CasComp concluded that to play a more leading, innovator role in the development of supply chains in the industry, they would need to add production to their service offering.

The CasComp also considered external factors as driving forces pushing them towards pursuing a PSS. CasComp carried out market research (independent from our research) and identified what CasComp referred to as "the expectancy of immediacy". In other words, customers were no longer willing to wait, and that customer delivery lead-time was an order qualifier. In the electronics industry, the CasComp found this demand for short lead times to be particularly acute: customers increasingly expect and demand access to the latest products and technologies on offer. The speed at which consumers simultaneously have access to information about new product introductions

(through social media platforms such as Twitter and Facebook) means that production companies lose a significant competitive advantage and lose orders if they are unable to get their products to customers at the same speed as their competitors.

The CasComp argued that many production companies had followed a strategy of off-shoring over the last 20 years and moved their production to large centralised mega-factories in Asia. Thus, they had moved their production further away from customer demand which in turn resulted in longer lead times. The CasComp argued that this placed manufacturing companies at a disadvantage when lead-time speed is an order qualifier. CasComp's analysis found that the demand for short lead times was driving manufacturing companies to consider locating their manufacturing closer to customer demand through a strategy of near-shoring or distributed manufacturing. Although manufacturing companies recognised the pressure to reduce lead times, moving their production from one central location in Asia to set up multiple factories around the world (distributed manufacturing) was considered a major challenge, as it required setting up new facilities and management teams around the world. In contrast, CasComp identified that they had an advantage to respond to this demand for shorter lead times, in that as a logistics service company, they had a management team and footprint already located closer to customer demand. Thus, by changing some of their facilities from logistics facility to production facilities, they were well positioned to make the most of this customer demand. Therefore, a driving factor for the CasComp was to take advantage of the customer demand for shorter lead times by providing a combination of distributed manufacturing and logistics services.

Another external factor identified by CasComp, which the company felt encouraged them to enter into manufacturing, was the identification of two macro-economic shifts that were disrupting the manufacturing landscape and opening up the

possibility of new manufacturing opportunities. The first was a trend of increasing labour costs in Asia, reflected in the research by Simchi-Levi (2015), who estimated that labour costs in China had increased annually by almost 20% compared to 3% in the United States and 5% in Mexico. The second macro-economic trend identified was related to energy prices. CasComp identified that increasing energy price volatility and the emergence of new techniques such as fracking had the potential to reduce energy prices in certain countries, and was starting to impact decision making on manufacturing locations. CasComp argued that major fluctuations in oil prices over the last decade (Nasdaq, 2015), caused cost uncertainty for manufacturing and supply chain decision makers, particularly those who currently relied on shipping products across the world.

Combined, the company reasoned that the two economic drivers together with the customer demand for shorter lead times were making companies who had centralised their manufacturing in Asia to consider distributing it to move it closer to customer demand. This further re-enforced the company's view that a logistics service provider, with its already existing global network of facilities was better positioned to take advantage of the distributed manufacturing trend and add a production offering, compared to a production companies that had a centralised manufacturing footprint to add a logistics service offering.

A further driving force for adding production capabilities to CasComp service offering was the growing availability and access to 3D printing (3DP) technology. The CasComp argued that 3DP technology reduced the barriers for the CasComp to enter into production services. Many manufacturing companies have built strong barriers to entry, either by building up large volumes (and achieving cost leadership through economies of scale and location in low cost geographies) or by developing technical

competencies in a particular production process. These cost leadership barriers are being broken down by the aforementioned macro-economic changes, and CasComp identified that new 3DP technologies could break down the barriers of technical competencies in existing manufacturing processes. CasComp identified 3DP as a technology that would allow them to accelerate their strategy of productisation. Developing traditional manufacturing capabilities has a high barrier to entry (due to high capital costs and skill set requirements), but the range of 3D Printers coming onto the market, reduced the barriers to entry, due to their relative low cost and due to the fact that, as they are new, incumbent manufacturers had not developed any uniquely superior capabilities.

Although the company made the decision to pursue a strategy of productisation based on commercial motivations, it did also consider the potential environmental benefits. In the supply chain set up illustrated in Figure 4, component manufacturing and assembly was often carried out in a central location in Asia, and finished goods storage was often carried out close to consumer demand. As electronics products have a very short product life cycle, a large proportion of goods are air-freighted between finished goods assembly and finished goods storage. Additionally, when a repair is required, products are often air freighted back to Asia in the return loop. These long transportation legs increase the risks of product obsolescence and often result in high levels of environmentally damaging air transportation. In the new proposed solution, CasComp would locate some of the manufacturing activities in their distribution centres, moving the manufacturing closer to customer demand. The result was that certain raw materials could be sourced locally, reducing the environmental impact of transportation. Furthermore, CasComp recognised that if it provided manufacturing close to consumer demand, it would be well placed to provide repair services for any

returned parts. Thus, the return and repair loop would be shorter, potentially further reducing environmental impacts.

4.3 Restraining forces for considering a strategy of productisation

Although the company found a strong argument to pursue a strategy of productisation, a number of restraining forces were identified and discussed by the management team. The initial concern raised by the company when considering the productisation strategy was if and how this fit with the company's core offering of freight services. Linked to this was the concern of whether the organisation had the required skills to be able to offer production services at all, and then, once offered, whether they had the capacity and scale to offer the services globally. As one CasComp manager explained *'the difference between running a manufacturing facility and a logistics service operation is huge, it requires a completely different management approach and skill-set'*. The company recognised that to offer a new production service, a new skill set and way of working would be required. In particular, the skills of running a manufacturing operation as well as product design capabilities were regarded as key skills that the CasComp would need to develop.

Another major concern was related to the new risks that the company would be taking on by offering production services, particularly product liability risk and risk of design copyright infringement. When considering the potential revenues from offering productisation services and the new risks that the offering would incur, the company were concerned that the risks could outweigh the potential revenue gains. Specifically considering 3DP services, the CasComp found that due to the infancy of the technology and the 3DP industry, the legal and contractual frameworks were still being developed. Consequently, uncertainty about these legal issues was a major restraining force.

Overall, due to the CasComp's inexperience at mitigating and managing these new risks, both from a legal and commercial perspective, this was a major restraining force for the CasComp.

Another restraining force related to concern about the CasComp's experience and knowledge of purchasing and maintaining machinery and equipment. There was a particular concern about the level of investment required to offer manufacturing services, and whether the company would have the scale to maximise the use of machines and equipment through a start-up and growth phase. The fast changing nature of manufacturing technologies, particularly 3D printing, was seen as a high risk, in that investment in the wrong type of equipment could result in high capital expenditure and limited revenue return.

One major consideration to CasComp offering production services was their customer's perception of CasComp's ability to successfully manage a production environment. As one customer noted, *'we don't see how a logistics company would have the necessary skills and quality culture to run a production operation after such a short time, when most manufacturing companies have taken decades to build and perfect quality standards'*. Of all of the restraining forces identified, this was perhaps the largest one for CasComp to overcome, as it required not just changing the mind-set of their internal team, but changing the mind-set of their customers too.

The forces provided here are not exhaustive and other factors such as a possible competitive response from the EMS/ODM companies and possible reputational damage if the strategy failed, were also considered by the CasComp, but were not highlighted as major restraining forces.

4.4 Bringing the driving and restraining forces into the conceptual framework

As the data collection focused only on identifying the driving and restraining forces, only the findings related to this section of the conceptual framework are provided here. The findings are presented in Table 4. However, the forces should be considered in light of the wider conceptual framework provided in the methodology section of this paper.

Table 4: Application of Conceptual Framework to CasComp Findings

Driving Forces (DF) ---->

	New factor?	Strength of force				
		1	2	3	4	
Limited potential to increase margins in their own, pure service industry		x	x	x	x	+4
Potential higher margin activities with combined service and production capabilities		x	x	x	x	+4
Opportunity to take a more leading, innovator role in supply chain development with the addition of production capabilities	New	x	x	x		+3
Geographically well placed (close to the customer) to be able to offer combined logistics and manufacturing services	New	x	x	x	x	+4
Experienced at developing functional delivery type contracts	New	x	x			+2
Customer demands for shorter lead times, which the 3PL was well placed to influence and improve	New	x	x	x		+3
Changing macro-economic factors that opened up the possibility to new manufacturing strategies	New	x	x	x		+3
Increased access to new technologies such as 3DP which reduce barriers to production	New	x	x			+2
Opportunity to bring environmental improvements to the supply chain		x				+1
TOTAL DRIVING FORCES						+26

<-- Restraining Forces (RF)

	New factor?	Strength of force				
		-1	-2	-3	-4	
Strategy did not fit with companies core service offering		x	x			-2
Company did not have the skills or capabilities to offer production services		x	x	x	x	-4
The new strategy increased overall company risk, especially product liability risk	New	x	x	x	x	-4
Lack of scalable capabilities	New	x				-1
Required investments in assets and machinery and lack of experience of procuring and maintaining equipment.	New	x	x	x	x	-4
Potential competitive response from existing manufacturing suppliers.	New	x				-1
Company culture and skill set		x	x	x		-3
Overcoming customer perception		x	x	x	x	-4
Lack of design capabilities	New	x	x			-2
TOTAL RESTRAINING FORCES						-25

NET FORCE

+1

The findings reveal several new driving and restraining forces, marked as “New” that have not been previously identified in the literature. The findings also reveal that some forces already identified in the literature as relevant for production companies are also applicable to service companies, for example the motivation to pursue a PSS to increase margins. This finding indicates there may be a level of generalisability and shared factors that apply to both production and service companies. Additionally, the framework also indicates that some factors identified in the PSS literature were not relevant for CasComp, for example CasComp did not perceive any major barriers related to the alignment of incentives with customers. We propose that this is because for service companies, this is a common challenge already in their business, and therefore not a factor specific to developing a PSS.

Furthermore, the conceptual framework provides a quantitative strength of each force. This provides new and additional insight into the relative importance of each factor for the CasComp, and also now allows a quantifiable measure of the net strength of the company’s desire to pursue a PSS (where positive driving factors are netted off against negative restraining factors). For the CasComp, which did elect to pursue the PSS productisation strategy, the positive driving factors only outweighed the restraining factors by one point (identified as the Net Force in Table 4). It is proposed that this low Net Force score contributed to the CasComp only electing to set a modest new target position and start to pursue the PSS on a small scale in a few pilot locations, rather than making ambitious targets and large scale change programmes.

5. Conclusions

We conclude that the topic of productisation and considering PSS from the perspective of a service provider represents an important gap in the PSS literature. More specifically, our research reveals that current PSS literature does not capture all of the relevant driving and restraining forces for a service company exploring the possibility of pursuing a PSS productisation strategy. Moreover, our research also reveals that there are some forces that, although derived from research into manufacturing companies, are not unique to these companies but are also applicable to service companies. This has research implications in that it reveals that there may be a level of generalisability to PSS research that has not been fully explored by researchers to date.

In addition, our research finds that applying force field analysis techniques is a useful way to quantify and measure the forces in play when considering creating a PSS. This finding is equally relevant for both service and production companies.

Our case study shows that PSS did provide a strategic opportunity for the service company. For the CasComp specifically, the strength of the driving and restraining forces were almost in equilibrium, indicating that the decision to pursue a PSS for the CasComp was not overwhelming or clear cut, but only slightly in favour of pursuing such a strategy. For the CasComp, this resulted in only a small step towards a PSS, but a step nevertheless.

The contribution of this paper is three-fold. First, our research broadens the perspective of PSS beyond that of the production company, revealing new driving and restraining forces to pursuing a PSS. Second, our research introduces a refined conceptual framework that makes a clearer distinction between the forces that influence a company's decision to pursue a PSS, and factors it may face when implementing the

strategy. Lastly, by introducing a force field analysis and net force score, we introduce the established method of force field analysis into the field of PSS.

6. Limitations

The methodology is not without limitations. In the literature review, we limited our search to only include papers that used the terms PSS and Product-Service System. We did not consider other homogeneous terms such as product-service mix or bundling. Even with this limitation, our initial literature search identified a large body of research on PSS, too large for us to read and classify all papers. By selecting only 90 papers for consideration, it is possible that some relevant papers were not considered.

For the case study methodology, we assessed our method in terms of design, analytical and inferential validity (Zachariadis et al. 2013, p. 860). With this, additional research limitations were identified. In particular in terms of design validity, the major limitation relates to transferability or generalisability of the research. Our case study was limited to one organisation and their focus of developing a PSS in one industry. It is noted that the empirical validity and utility of our conclusions need to be assessed in other companies and other industries.

Additionally, our case study method of participant observation had potential for bias (Yin 2009). For example, the participant observers may not have enough time to make notes or raise questions since they are so much focused on “participating”. The participant observer is also prone to become a supporter of the group or organization being studied. To avoid the observer bias, the participant observer worked closely with the wider researcher team to validate their interpretation (Saunders et al. 2012) of the data collected.

Lastly, the quantification of the driving and restraining forces was decided upon by the research team based on the qualitative data collected during the participatory

observation sessions. A more refined and robust method to quantify the forces would need to be sought, and in the future, we would also recommend higher involvement of the CasComp management team in the quantification of the factors.

7. Discussions and avenues for further research

Our research leads us to suggest that much more research needs to be done to understand PSS from a service provider perspective. In this paper, only one part of the conceptual framework, that of understanding the driving and restraining forces to decide to pursue a PSS is researched. The broader conceptual framework provides a number of new potential research streams. For example, the first step in the conceptual framework asks “what do you do today?” A focus on this question would allow researchers and practitioners to develop means of assessing the current capabilities of both production and service companies against the requirements of developing a successful PSS. This in turn could lead to interesting research to assess which company is best positioned to achieve the PSS, rather than the approach taken today in which there is a tacit assumption that the production company is the best positioned.

Furthermore, this paper has focused on the question of why a service company may elect to pursue a PSS; it does not address the equally important question of whether or not this is a strategically good decision. For the CasComp, it was too early to draw conclusions on whether the decision was the right one or not, and although this key question remains unanswered, the research done for this paper does provide the foundations to create a better understanding of the impact the driving and restraining forces have on both the target position that the company sets itself, and also its ability to implement it. This leads to further important questions, not yet addressed in the literature, such as whether setting an ambitious target and implementing a bold

transformation plan is more likely to be successful than taking a more cautious, step-by-step approach to developing a PSS.

In this paper, we have explored the possibility of a logistics company developing their own PSS through a productisation strategy. The research carried out for this paper also leads us to believe that the growing trend of manufacturing companies moving towards PSS business models may provide logistics providers with alternative strategies to benefit from this trend. For example, research by Zhang et al. (2016) demonstrate the potential for logistics companies to develop PSS to support existing manufacturers by using smart PSS boxes, and work by Szwejcowski et al. (2015) indicates the growing importance of repair and after sales services in PSS solutions, another area that may provide logistics providers with an opportunity for growth.

Lastly~~In the longer term~~, we see significant potential to research the complete journey of both production and service companies through each of the steps in the conceptual framework. With a deeper understanding of the journey taken by different organisations, researchers and practitioners can work together to ~~find~~^{find} creative solutions to identify and overcome the critical restraining forces of developing a PSS.

8. References

- Aurich, J.C., Roy, R., Shehab, E., Tiwari, A., Wolf, N., Siener, M., Schweitzer, E., 2009. Configuration of product-service systems. *J. Manuf. Technol. Manag.* 20, 591–605.
- Baines, T., Lightfoot, H.W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., 2007. State-of-the-art in product-service systems. *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.* 221, 1543–1552.
- Baines, T., Roy, R., Shehab, E., Tiwari, A., Lightfoot, H.W., Benedettini, O., Kay, J.M., 2009. The servitization of manufacturing: A review of literature and reflection on future challenges. *J. Manuf. Technol. Manag.* 20, 547–567.
- Barquet, A.P.B., de Oliveira, M.G., Amigo, C.R., Cunha, V.P., Rozenfeld, H., 2013. Employing the business model concept to support the adoption of product-service systems (PSS). *Ind. Mark. Manag.* 42, 693–704.

- Battaglia, D., Borchardt, M., Patrício, L., 2016. PSS Offering in a B2B Context: Towards the Drivers to Enable Integrated Solutions. *Procedia CIRP* 47, 400–405.
- Belvedere, V., Grando, A., Bielli, P., 2013. A quantitative investigation of the role of information and communication technologies in the implementation of a product-service system. *Int. J. Prod. Res.* 51, 410–426.
- Beuren, F.H., Ferreira, M.G.G., Miguel, P.A.C., 2013. Product-service systems: a literature review on integrated products and services. *J. Clean. Prod.* 47, 222–231.
- Burnes, B., Cooke, B., 2013. Kurt Lewin's Field Theory: A Review and Re-evaluation. *Int. J. Manag. Rev.* 15, 408–425.
- Chattopadhyay, N., 2012. Productisation of Service : A Case Study. *Int. J. Of Advanced Comput. Sci. Appl.* 3, 197–201.
- Cherubini, S., Iasevoli, G., Michelini, L., 2015. Product-service systems in the electric car industry: critical success factors in marketing. *J. Clean. Prod.* 97, 40–49.
- Cook, M., Gottberg, A., Angus, A., Longhurst, P., 2012. Receptivity to the production of product service systems in the UK construction and manufacturing sectors: a comparative analysis. *J. Clean. Prod.* 32, 61–70.
- Cook, M.B., Bhamra, T.A., Lemon, M., 2006. The transfer and application of Product Service Systems: from academia to UK manufacturing firms. *J. Clean. Prod.* 14, 1455–1465.

[Coreynen, W., Matthyssens, P., De Rijck, R., Dewit, I., 2017. Internal levers for servitization: How product-oriented manufacturers can upscale product-service systems. *Int. J. Prod. Res.* 1–15.](#)

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Justified

Formatted: Normal, Left

- Denzin, N.K., 1978. *Sociological methods: A sourcebook*. McGraw-Hill Companies. New York
- DeWalt, K.M., DeWalt, B.R., 2011. *Participant observation: A guide for fieldworkers*. Rowman Altamira, Plymouth, UK.
- Evans, S., Partidário, P.J., Lambert, J., 2007. Industrialization as a key element of sustainable product-service solutions. *Int. J. Prod. Res.* 45, 4225–4246.
- Gamst, F.C., 1980. Toward a method of industrial ethnology. *Rice Inst. Pam.-Rice Univ. Stud.* 66.
- Gebauer, H., Fleisch, E., Friedli, T., 2005. Overcoming the service paradox in manufacturing companies. *Eur. Manag. J.* 23, 14–26.
- Goedkoop, M., Van Halen, C.J., Te Riele, H., Rommens, P.J., 1999. Product service systems, ecological and economic basics. *Rep. Dutch Minist. Environ. VROM Econ. Aff. EZ* 36, 1–122.
- Harkonen, J., Haapasalo, H., Hanninen, K., 2015. Productisation: A review and research agenda. *Int. J. Prod. Econ.* 164, 65–82.
- Holmström, J., Partanen, J., 2014. Digital manufacturing-driven transformations of service supply chains for complex products. *Supply Chain Manag. Int. J.* 19, 421–430.
- Isaksson, O., Larsson, T.C., Rönnbäck, A.Ö., 2009. Development of product-service systems: challenges and opportunities for the manufacturing firm. *J. Eng. Des.* 20, 329–348.
- Kandampully, J., 2002. Innovation as the core competency of a service organisation: the role of technology, knowledge and networks. *Eur. J. Innov. Manag.* 5, 18–26.

- Kuo, T.C., Ma, H.-Y., Huang, S.H., Hu, A.H., Huang, C.S., 2010. Barrier analysis for product service system using interpretive structural model. *Int. J. Adv. Manuf. Technol.* 49, 407–417.
- Leoni, L., 2015. Servitization and Productization: two faces of the same coin? Conference RESER 2015. ISBN 978-87-7349-921-4
- Leseure, M., Hudson-Smith, M., Martinez, V., Bastl, M., Kingston, J., Evans, S., 2010. Challenges in transforming manufacturing organisations into product-service providers. *J. Manuf. Technol. Manag.* 21, 449–469.
- Lewin, K., 1951. *Field theory in social science: Selected theoretical papers* (Edited by D. Cartwright.). New York: Harper & Row.
- Liu, H., Chen, C., Tu, M.-C., Wang, Y.-H., Chu-Ching, 2014. Constructing a sustainable service business model: An SD logic-based integrated product service system (IPSS). *Int. J. Phys. Distrib. Logist. Manag.* 44, 80–97.
- Lockett, H., Johnson, M., Evans, S., Bastl, M., 2011. Product Service Systems and supply network relationships: an exploratory case study. *J. Manuf. Technol. Manag.* 22, 293–313.
- Long, H.J., Wang, L.Y., Shen, J., Wu, M.X., Jiang, Z.B., 2013. Product service system configuration based on support vector machine considering customer perception. *Int. J. Prod. Res.* 51, 5450–5468.
- [Mahut, F., Daaboul, J., Bricogne, M., Eynard, B., 2017. Product-Service Systems for servitization of the automotive industry: a literature review. *Int. J. Prod. Res.* 55, 2102–2120.](#)
- [Matschewsky, J., Kambanou, M.L., Sakao, T., 2017. Designing and providing integrated product-service systems—challenges, opportunities and solutions resulting from prescriptive approaches in two industrial companies. *Int. J. Prod. Res.* 1–19.](#)
- Maxwell, D., Sheate, W., van der Vorst, R., 2006. Functional and systems aspects of the sustainable product and service development approach for industry. *J. Clean. Prod.* 14, 1466–1479.
- Mindtools, Force Field Analysis. https://www.mindtools.com/pages/article/newTED_06.htm (Accessed 15/6/2017)
- Mont, O., 2000. Product-Service Systems. *Int. Inst. Ind. Environ. Econ. Lund Univ.*
- Mont, O., 2002a. Clarifying the concept of product–service system. *J. Clean. Prod.* 10, 237–245.
- Mont, O., 2002b. Drivers and barriers for shifting towards more service-oriented businesses: Analysis of the PSS field and contributions from Sweden. *J. Sustain. Prod. Des.* 2, 89–103.
- Nasdaq, 2015. Nasdaq Crude Oil Index [WWW Document]. [Httpwwwnasdaqcommarketscrude-Oil.aspx](http://www.nasdaq.com/markets/crude-oil.aspx). URL <http://www.nasdaq.com/markets/crude-oil.aspx> (accessed 7.10.15).
- Nudurupati, S.S., Lascelles, D., Yip, N., Chan, F.T., 2013. Eight challenges of the servitization, in: *The Servitization (PSS) Conference*. pp. 8–14.
- Oliva, R., Kallenberg, R., 2003. Managing the transition from products to services. *Int. J. Serv. Ind. Manag.* 14, 160–172.
- Penttinen, E., Palmer, J., 2007. Improving firm positioning through enhanced offerings and buyer–seller relationships. *Ind. Mark. Manag.* 36, 552–564.
- Pereira, V.R., de Carvalho, M.M., Ribeiro, J.L.D., 2013. Product-service system–PSS: a study of business drivers. *Conf. Pap. Accessed Res. Gate*.

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Justified

- Pessôa, M.V.P., Becker, J.M.J., 2017. Overcoming the Product-Service Model Adoption Obstacles. *Procedia CIRP* 64, 163–168.
- Phumbua, S., Tjahjono, B., 2012. Towards product-service systems modelling: a quest for dynamic behaviour and model parameters. *Int. J. Prod. Res.* 50, 425–442.
- Ramalingam, B., 2006. Tools for knowledge and learning: A guide for development and humanitarian organizations. Overseas Development Institute London.
- Reim, W., Parida, V., Örtqvist, D., 2015. Product–Service Systems (PSS) business models and tactics—a systematic literature review. *J. Clean. Prod.* 97, 61–75.
- Resta, B., Powell, D., Gaiardelli, P., Dotti, S., 2015. Towards a framework for lean operations in product-oriented product service systems. *CIRP J. Manuf. Sci. Technol.* 9, 12–22.
- [Rondini, A., Tornese, F., Gnoni, M.G., Pezzotta, G., Pinto, R., 2017. Hybrid simulation modelling as a supporting tool for sustainable product service systems: a critical analysis. *Int. J. Prod. Res.* 1–14.](#)
- Rothenberg, S., 2007. Sustainability through servicizing. *MIT Sloan Manag. Rev.* 48, 83.
- Saunders, M., Lewis, P., Thornhill, A., 2012. *Research Methods for Business Students*, 6th ed. Mark Saunders, Philip Lewis and Adrian Thornhill, London.
- [Shen, J., Erkoyuncu, J.A., Roy, R., Wu, B., 2017. A framework for cost evaluation in product service system configuration. *Int. J. Prod. Res.* 1–25.](#)
- Simchi-Levi, D., 2015. You Can't Understand China's Slowdown Without Understanding Supply Chains. *Harv. Bus. Rev.*
- Song, W., Ming, X., Han, Y., Wu, Z., 2013. A rough set approach for evaluating vague customer requirement of industrial product-service system. *Int. J. Prod. Res.* 51, 6681–6701.
- Spring, M., Araujo, L., 2009. Service, services and products: rethinking operations strategy. *Int. J. Oper. Prod. Manag.* 29, 444–467.
- Swanson, D.J., Creed, A.S., 2014. Sharpening the focus of force field analysis. *J. Change Manag.* 14, 28–47.
- [Szwajczewski, M., Goffin, K., Anagnostopoulos, Z., 2015. Product service systems, after-sales service and new product development. *Int. J. Prod. Res.* 53, 5334–5353.](#)
- Tukker, A., 2004. Eight types of product–service system: eight ways to sustainability? Experiences from SusProNet. *Bus. Strategy Environ.* 260, 246–260.
- Tukker, A., Tischner, U., 2006. Product-services as a research field: past, present and future. Reflections from a decade of research. *J. Clean. Prod.* 14, 1552–1556.
- White, A.L., Stoughton, M., Feng, L., 1999. *Servicizing: the quiet transition to extended product responsibility*. Tellus Inst. Boston 97.
- Yin, R.K., 2009. *Case study research: design and methods*, 4th ed. Sage. Thousand Oaks, CA
- Zachariadis, M., Scott, S.V., Barrett, M.I., 2013. Methodological Implications of Critical Realism for Mixed-Methods Research. *MIS Q.* 37, 855–879.
- [Zhang, Y., Liu, S., Liu, Y., Li, R., 2016. Smart box-enabled product-service system for cloud logistics. *Int. J. Prod. Res.* 54, 6693–6706.](#)

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Justified

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Justified

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Justified

Formatted: Normal, Left