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DOI:

[10.1080/09537287.2015.1128571](https://doi.org/10.1080/09537287.2015.1128571)

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Document Version

Peer reviewed version

Citation for published version (Harvard):

He, T, Ho, W, Zhang, Y & Dey, P 2016, 'Organising business processes of a product servitised supply chain: a value perspective', *Production Planning & Control: The Management of Operations*, vol. 27, no. 5, pp. 378-393. <https://doi.org/10.1080/09537287.2015.1128571>

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Publisher Rights Statement:

This is an Accepted Manuscript of an article published by Taylor & Francis in *Production Planning & Control* on 12th January 2016, available online: <http://www.tandfonline.com/10.1080/09537287.2015.1128571>

Checked Feb 2016

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Organising the Business Processes of a Product Servitised Supply Chain: A Value Perspective

T He, W. Ho, Y Zhang, P. Dey

This paper develops a structured method from the perspective of value to organise and optimise the business processes of a product servitised supply chain (PSSC). This method integrates the modelling tool of e³value with the associated value measurement, evaluation and analysis techniques. It enables visualisation, modelling and optimisation of the business processes of a PSSC. At the same time, the value co-creation and potential contribution to an organisation's profitability can also be enhanced. The findings not only facilitate organisations that are attempting to adopt servitisation by helping avert any paradox, but also help a servitised organisation to identify the key business processes and clarify their influences to supply chain operations.

Keywords: product servitised supply chain (PSSC); product-service value (PSV); e³value modelling; servitisation paradox

1. Introduction

As sustainable production and consumption have become increasingly important in the current business environment, this has led to the transformation of market structures and competitive situations into the direction of servitisation (Kreye, Newnes, and Goh 2014). Unfortunately, this promising transformation has not been successful for many servitised firms so far. Manufacturers that see the provision of services as being the key to their future are facing significant challenges (Baines et al. 2012). For example, in a study of a global sample of 10846 manufacturing firms, it has been shown that the servitised manufacturing firms appear more likely to be declared bankrupt than in the case of pure manufacturing firms (Neely 2008). The empirical research evidence has raised the issue of a "servitisation paradox" which means that substantial investment in extending service business leads to increased service offerings and higher costs, but does not generate the expected higher returns (Gebauer, Fleisch, and Friedli 2005; Reinartz and Ulaga 2008; Neely 2010).

Over the past decade, the literature especially in the domains of supply chain management, operations management and information systems has suggested theories, guidance and practice for organisations about either what should be done for overcoming this servitisation paradox, or what are essential steps to the successful delivery of a servitisation strategy in terms of its business strategy, service capability, organisational structure, culture and mind-set from the strategic or operational perspectives (Gebauer, Fleisch, and Friedli 2005; Brady, Davies and Gann 2005; Neely 2008; Baines, Lightfoot and Kay 2009b; Gaiardelli et al. 2014; Lightfoot, Baines, and Smart 2013; Park, Geum, and Lee 2012). These contributions provide valuable guidance to servitisation at a strategic level. However, the literature still lacks works that provides the tools and techniques that can be used by servitised organisations

to develop and deliver their business offerings effectively (Rapaccini and Visintin 2014).

Apparently, it is not clear how manufacturers can ensure the success of their services as secondary to tangibles (Nordin et al. 2011; Ulaga and Reinartz 2011), and this leads to failures in servicing operations, and impedes the establishment of a convincing and profitable service business (Brax 2005). He et al. (2012) suggested that despite the extensive goods-centric supply chain operations studies, they are not applicable to the product servitised supply chain (PSSC) due to the significant difference between servicing and manufacturing operations (Mark and Carlos 2008). Therefore, to overcome the servitisation paradox, manufacturers need to re-understand how customers value their services (Gebauer, Fleisch, and Friedli 2005). They also need to be able to configure their products, technologies, operations, and supply chains to support this value process of value creation and delivery (Baines et al. 2007). Furthermore, the transformation from the conventional business concept of design, manufacturing and selling physical products to offering integrated product-service bundle necessitates the creation of a service delivery system, and subsequently, a redesign of the value chain so that it is capable of delivering the proposed value to the customer (Windahl et al. 2004).

Our research has been underpinned by a value perspective, since the creation of value is paramount to any company's survival, especially when dramatic changes lead to fundamental shifts in what companies analyse, create, and deliver (Kotler and Keller 2008; Lindgreen et al. 2012). Few studies have investigated how firms create value when they add services to the traditional manufacturing operations (Bustinza, Parry, and Vendrell-Herrero 2013), even less on identifying how much value is created in these business processes. Particularly, the concept of value co-creation in a supply chain was examined with an empirical dataset of 110 supplier and client relationships in the latest online publication of PPC (Ren et al. 2015). We would expect

this paper to provide further understanding and techniques on how to properly integrate the concept of value in supply chain modelling and optimisation in general and validate this method with an in-depth case focusing on servitisation.

Business process modelling and the evaluation of different alternative scenarios (TO-BE models) for improvement by simulation are usually the driving factors of the business renovation process (Bosilj-Vuksic et al. 2002). Therefore, to aid in the offering of solutions for the effective servitisation and operations for a traditional product supply chain, we intend to contribute to the organizing business processes of PSSC from the value perspective, and therein, seek to develop a structured method for PSSC managers to operate their businesses effectively. The main objective is to understand how to effectively organise the business processes, and improve the value created or performance of PSSCs quantitatively using the case-based action research method (Platts 1993; Yin 2013).

This paper is organised into five sections with the following section reviewing the literature on business process modelling, and performance/value measurement in supply chain management (SCM). Section 3 provides a comprehensive view of PSSC and product-service value (PSV) through analysing the existing models and concepts and addressing the essence of servitisation. The method used to interpret and quantify value is also introduced. Furthermore, a structured method to organise the business processes of PSSC is presented. In Section 4, this method is validated and refined by our case study of a servitised carpet supply chain. This paper concludes with a brief summary of the key findings and discussions towards future research.

2. Literature Review

2.1. *Business process modelling methods for service organisations or servitisation*

For traditional manufacturers, as they provide product-service offerings into the marketplace it therefore necessitates the shift of existing organisational structures and processes (Baines, Lightfoot, and Kay 2009b). During this shift, it must be taken into account that the productivity of services primarily depends on effective and efficient business processes within a supply chain (Kowalkowski 2006). A servitising organisation has to design processes for the delivery of industrial services that are replicable and profitable (Galbraith 2002).

Business process modelling has been proven to be a valuable instrument for designing, managing and improving an organisation's activities and processes (Presley and Liles 2001). The process paradigm implies a new way of looking at organisations based on the processes they perform rather than on the functional units,

divisions or departments they are divided into (Trkman et al. 2007). There are various process description methods for enterprises. They range from a mere verbal description to process representations that have a graphically structured approach.

The conventional process modelling methods include mainly the following: a verbal description method, a graphical-verbal representation method, the graphical-structural techniques of flow charts, a united modelling language (UML), and event-driven process chains, etc. Langer et al. (2009) concludes that these approaches have severe shortcomings in modelling service processes in manufacturers and thus cannot support them effectively in transition to becoming solution-providers (Biege, Lay, and Buschak 2012).

Service Blueprinting is a service oriented process modelling technique which has been developed to describe, document and analyse service processes in service firms. Compared with the aforementioned process description methods, it can be used for studying interactive service processes, and integrate the customers' perspectives into a map and show their service perception. Service Blueprinting is helpful for analysing interactions, rather than showing how interactions fit within a broader picture of the processes performed and shared by multiple entities, and thus having a limited ability to provide an overview for the whole network (Sampson 2012).

To summarise the existing studies in this area, Biege et al. (2012) compiled an overview of advantages and disadvantages of the existing process modelling methods by concerned servitised manufacturers in light of the criteria that derive from the service, product and hybrid requirements of servitised manufacturers. This reveals that none of the existing methods is applicable to the particular needs of manufacturers for bundling products and services.

Recently, Sampson (2012) proposed a Process Chain Network framework (PCN) which improves on the Service Blueprinting in three fundamental ways. It is a rigorous design tool used in designing a service system that helps practitioners and researchers visualize and analyse their service operations problems, including phenomena that otherwise might be difficult to be conceptualised. In brief these tools and methods fall short in finding the right partners and organizing the new co-operations efficiently. We still need further analysis by concentrating on quantitative methods that will help participants without any experience of using a new PSS model (Boehm and Thomas 2013).

The e³alignment technique suggested by Pijpers et al. (2009) could be a proper process modelling technique for PSSC which explores a wide range of inter-organisational alignment issues concerning the interaction between organisations in a value web. By

aligning the interactions qualitatively or quantitatively between organisations, e³alignment can create a sustainable and profitable value web. Its real power comes from understanding what goes on in the various process actors, and how its process chains can be configured and managed to provide superior value to customers and providers by analysing and optimising interactive service processes, and also identifying strategic opportunities for process improvement. These are exactly what an appropriate business process modelling tool should have for PSSC. However, before we could possibly employ e³alignment in our research, we had to properly interpret and measure value for this method, because value is not an original element in the existing e³alignment method.

2.2. Performance or value measurement in SCM

Performance measurement has been one of the main concerns for SCM (Giannakis 2007). It provides an approach to identifying the success and potential of management strategies and can assist in directing management attention, revising business goals and reengineering the business process (Chan and Qi 2003a). As Sink and Tuttle (1989) contended: “You can’t manage what you cannot measure”. Therefore, “How to measure performance across supply chains rather than within organisations” has become a very important research area (Neely 2005).

2.2.1. The “Performance Measurement System (PMS)” method

The importance of this topic emerges from the assumption that PMS is an essential tool to enable a company to achieve and control its desired objectives. There are two main clusters in the PMS literature- the first one is dominated from a pure financial and accounting perspective, while the second one implies using qualitative measures of performance. The latter cluster is also called the balanced or integrated approaches for measuring performance due to the combination between qualitative and quantitative measures of performance into one single system (Olve, Roy, and Wetter 1999; Zeglal et al. 2012).

In terms of using PMS, Phillips et al. (1999) claimed that determining how to measure business performance is not an easy task for two reasons: difficulties in finding definitions for performance, competitiveness, effectiveness, and other related concepts, and difficulties in finding measures and metrics for such concepts. Despite these difficulties, several balanced frameworks and integrated models for measuring business performance are presented such as the Balanced Scorecard Framework (Kaplan and Norton 1992), the Performance Prism System (Neely, Adams,

and Crowe 2001), Dynamic Multidimensional Performance (Maltz, Shenhar, and Reilly 2003), Transforming Performance Measurement (Spitzer 2007), etc. Especially in regard to this, Chan and Qi (2003b) have proposed a framework for performance assessment, based on three quantitative measurements (cost, resource utilization and quality) and four qualitative measurements (flexibility, visibility, trust and innovativeness). In addition, Jähn (2009) presents an approach for the enterprise-related analysis of selected performance parameters based on a value-added process-related perspective. This research focuses on the management and control of SME-based production processes: the measurement, evaluation and utilisation of the performance of a traditional product provider.

Considering the “diversity of PMS concepts” and their “difficulty and complexity”, Franco-Santos et al. (2007) stated that any researches in this area had to be constrained by a limited generalisability and comparability. For PSSC, the integration of tangible and intangible performance measures undoubtedly adds to the complexity and difficulty of managing supply chain PMS, especially when managers have to cope with the dynamic nature of performance measures and metrics within these systems (Bai et al. 2012).

2.2.2. The value measurement method

Effective value creation is paramount to the survival of an organisation (Kotler and Keller 2008), especially when dramatic changes lead to fundamental shifts in what companies analyse, create, and deliver (Doyle 2000). For servitised organisations, the value measurement method can help them calculate their output and subsequently evaluate their servitisation, as can be deduced from the definition of servitisation in the article “servitisation of business: adding value by adding services” (Vandermerwe and Rada 1988).

Lindgreen et al. (2012) mentioned the difficulty to provide a single, consensus definition of value. That is perhaps not the most critical task as long as we can properly interpret value in the particular context of PSSC. From the multi-perspective views of financial, non-financial or a mixture of both benefits such as value-in-use, economic value, product value, perceived value, etc., there exist various value measurement methods. Different metrics that align with the different strategies used are applied to supply chain growth and performance (Elizabeth 2008). For example, Fine et al. (2002) have developed a value assessment model for the General Motors powertrain organisation which is a hybrid based on the Economic Value Added Model. To broaden the performance measurement of the supply chain, Elizabeth (2008) has presented a conceptual model that incorporates a holistic view of value from all

the participants and their integrative value adding services. This integrative model attempts to provide a more “balanced” approach to measuring the value adding areas of a value chain where value can be found in both tangible and intangible areas of the chain. Fiol et al. (2011) have developed a measurement scale that demonstrated that the aspects of a functional character, together with other aspects of emotional and social nature, have a decisive influence on the perceived value of the exchange relationships among firms within the Spanish ceramic tiles cluster.

In brief, there is a dearth of studies focusing on the measurement or evaluation of business processes to support PSSC in the transformation of servitisation. At the same time, since performance measurement systems vary in different business environments, we would like to argue the need to modifying the existing methods by addressing the unique nature for PSSC (Bayraktar et al. 2007).

2.3. Synthesis of the literature

The extensive literature on business process modelling, PMS and value measurement provide a good foundation for understanding how to configure an operations strategy for PSSC; but they are in themselves insufficient to offer a complete and workable solution on how to effectively organise a product-service business process system, and properly direct their performance improvement programmes. Especially, we had to cope with some critical challenges about PMS and value measurement in a supply chain context, including the lack of a balanced approach to integrating financial and non-financial measures, or a systematic approach to managing PSSC as one whole system (Chan and Qi 2003b). Adding services to the product portfolio of an organisation may bring benefits, but the organisation has to reconsider its supply chain management approach (Bustanza, Parry, and Vendrell-Herrero 2013).

3. The value oriented method of organising business processes for PSSC

3.1. The overall research approach

We developed an organising business process method for PSSC to address the key knowledge gaps discussed in the previous section. A three-stage research approach was adopted as the existing studies in this area were remained largely at a conceptual level and fragmented. Our research began with the 1st stage literature review to explore the existing methods and techniques relevant to our research focusing mainly on the areas of supply chain management, operations management and information systems. The 2nd stage was to develop a

conceptual model for PSSC from the perspective of value; and the 3rd stage was to validate and refine the conceptual model in a specific operations context through an in-depth case study with a carpet manufacturing company. The theoretical development of our research was not a simple linear process across these three stages. There were actually a lot of iterative learning loops among these three stages to refine the conceptual model with case data, and to update the case analysis for some more valuable theoretical/practical implications. We decided to structure this paper in a rather straightforward manner to make it easier for readers to follow the main flow of research from the literature review, to conceptual development and then case study validation.

The overall logic and rationale underpinning our theoretical development is introduced as following. In order to organise the business processes of a PSSC effectively, we first need a comprehensive understanding of the key elements and the associated measures of PSSC and PSV. Second, we need a suitable PSSC business process modelling tool from the value perspective. Then, we can develop a value oriented method integrating the modelling tool with the related value/performance measures to effectively organise and optimise the business processes for PSSC.

3.2. The PSSC

The essence of servitisation, PSS or other analogous concepts is to integrate the various resources of participants (including customers) into a supply-demand product-service chain to create more value for all participants and our society than the conventional production mode. Therefore, we prefer to use the terminology of PSSC for the traditional product supply chain’s servitisation in this study.

As aforementioned, there exist various concepts about PSSC and its synonyms. However, these concepts need to be improved and adapted, and as Aurich et al. (2010) suggested, in spite of the growing prevalence of the PSSC in academic research, the subject had yet to be comprehensively defined. Therefore, we suggested the following working definition of PSSC for our study through integrating the current research on servitisation, PSSC and their synonyms (Vandermerwe and Rada, 1988; Tukker 2004; Mark and Carlos 2008; Maull, Smart, and Liang 2014; Boehm and Thomas 2013). PSSC refers to a platform that integrates and utilizes the resources of suppliers and customers to co-create the customized and flexible bundling of products and services throughout its lifecycle. It aims at creating customer utility and adding values by adding services to products for all the stakeholders as well as differentiating itself from competitors, establishing

stronger customer loyalty, creating continued service revenue streams and reducing environmental impact. Compared with the product supply chain, PSSC is especially characterized by increased levels of customer utility and adding value centrality by adding services to products throughout the product-service lifecycle (Mark and Carolos 2008; Maull, Smart, and Liang 2014; Ren et al. 2015).

3.3. The product-service value (PSV) of PSSC

The purpose of PSSC is to generate the best value for the customers and organisations involved. However, the producer's sense of value differs from that of the user, i.e. there are various forms of value for the same item. It is therefore important to clarify the concept of PSV by understanding the different angles of value from various disciplines.

In Economics and Value Engineering, the consensus of value is defined as the measure or judgment of evaluating the degree of the risk-benefit of things and value is the ratio of function to cost. Here, function is the utility for the tangible products while it is the effect or performance to be achieved for the intangible service (Zhao et al. 2008).

The Marketing literature consists of two main streams about the concept of value: the value of goods and services, and the value of relationships (Lindgreen et al. 2012). For example Woodruff (1997) stated value means customer value of a customer's perceived preference and evaluation of those product attributes, attribute performances, and consequences arising from that use that facilitates (or blocks) achieving the customer's goals and purposes in use situations; By focusing on the consumption values, Sheth, Newman and Gross (1991) developed the consumption values model theory which explains why consumers buy a product or not, why they prefer one product to another and why they prefer a specific brand. Kotler (2003) proposed the concept of perceived value which includes perceived benefits of the product minus both the product price and the costs of owning it. Neap and Celik (1999) suggested that product value reflects the buyer's desire to obtain the product. It is the product's cost, plus a subjective marginal value. This definition differs from others, in that the cost is not subtracted from benefits, but rather offers a sort of objective indicator of those benefits; Walter et al. (2001) stated that value entails the perceived trade-off among multiple benefits and sacrifices in a customer relationship.

In Business Management, value is often viewed as performance, and this implies that different literature has different definitions about value. In addition, in contrast with the Marketing Management Framework and SDL approach, Ford and Mouzas (2013) developed

a framework for service and value creation as a systemic interactive process of multiple, reciprocal and sequential problem-coping with the effects being seen on a number of levels, where service in the business landscape is a systemic process producing different positive and negative value for multiple actors.

Service Science is the study of service systems, and of the value co-creation within complex constellations of integrated resources (Spohrer and Maglio 2008). Vargo et al. (2008) defined value in terms of the improvement in service system well-being which can be measured in terms of a system's adaptability or ability to fit. They focus on value-in-use and in-context, and suggest that the service system simultaneously accesses, adapts and integrates resources to create value for themselves and others. However, many problems remain, value is still an elusive term and most indicators of service value fail to conceptualize it correctly because the service value construct is not typically exact (Vargo, Maglio, and Akaka 2008; Ruiz et al. 2008).

Apparently, the above studies are helpful to understand the concept of value, but will need some adaptation for our research as PSSC is the bundling of the product supply chain with the service supply chain. The essence of PSSC is to create value for all the participants of servitisation. The emphasis of PSSC operations is in the whole processes of co-creating, accumulating and exchanging values among PSSC participants. Based on the Global Supply Chain Forum, the Mentzer Model, and the product-centric servitised operations process (Lambert, García-Dastugue, and Croxton 2005; Mentzer et al. 2001; Baines et al. 2009b; Maull, Smart and Liang 2014), the proposed functional silos of PSSC includes the processes of marketing, research and development, sourcing, production, distribution/delivery and sustained service. Each process runs cross-functionally, cutting through functional silos within each organisation (Croxton et al. 2001), and can be further broken down into a series of sub-processes, thus providing the blueprint for the implementation of the PSSC framework.

Considering the value co-creation processes and functional silos of PSSC, we interpreted the PSV (Table 1) for PSSC with reference to the above discussions on the concept of value, especially a number of key literature including Sheth et al.(1991), Vargo et al. (2008), Rapaccini and Visintin (2014), Lindgreen et al. (2012), Park et al. (2013) and Barber (2008). In this interpretation, value for PSSC has been classified into two categories: internal PSV and external PSV wherein the internal value is the value co-created by the co-production processes of PSSC, and where the external value depends on external conditions and circumstances, which is embodied by the benefit perceived from customers and other external stakeholders.

Table 1. The PSV indicator system for PSSC

Value category	Value class	Interpretation	Example services and their attributes
Internal product-service value (IPSV)	Product based functions	Perceived utility acquired from an alternative's capacity for functional, utilitarian or physical performance	Usability, practicability, diversity, advancement, economy, adaptability, appearance, comfortableness, safety, scarcity, durability, maintainability, environment protection, etc.
	Services	Product based services or pure services	Service content diversity, service pattern, condition, capability, environment, effect, follow-up services
	Responsiveness	Speed at which a supply chain provides product-service to the customer	Response time, efficiency, service cycle time, etc.
	Reliability	Performance in delivering the correct product to the correct place at the correct time in the correct condition and packaging in correct quantity with correct document to the correct customer	Durability, applicability, usability, availability, assurance level, etc.
	Flexibility	Agility of a supply chain in responding to marketplace changes	Service resource substitutability, etc.
External product-service value (ESPV)	Social value	Perceived utility acquired from an alternative's association with one or more specific social groups	Related with terms such as social class, symbolic value, conspicuous consumption, reference groups and opinion leadership
	Emotional value	Ability of product or service generates feelings or affective states	Feelings or emotional reactions against components like "situations, products, advertisements and brands"
	Epistemic value	Perceived utility acquired when the product-service arouses curiosity, provides novelty and / or satisfies a desire for knowledge	Experienced curiosity, novelty or gained knowledge
	Conditional value	Depends on the context, exists only in a specific situation, context includes any information which characterizes a situation related to the interaction between human, applications and the environment	Product-service for the "celebrations, festivals and special days".
	Environmental value	Ability to reduce emission, pollution and consume less for sustainability	Carbon-emission reduction, green product, energy conservation etc.

3.4. Quantifying the PSV of PSSC

How to effectively identify, assess and measure value has become a critical task in our research due to the lack of a commonly accepted interpretation of value (Vargo, Maglio, and Akaka 2008; Baines et al 2009a; Lindgreen et al. 2012; Park, Park, and Essouky 2013). This in turn leads to the difficulty to ascertain the measurement metrics for PSSC. There were some studies targeting at this issue. For example, according to Chan and Qi (2003b), the quantitative supply chain performance measures may be categorized by the objectives that are based on cost or profit, measures of customer responsiveness, and productivity. Then a mathematics model that employs a fuzzy set theory is proposed to measure the integrated supply chain performance. In the service context, Ladhari (2009) recommends that the SERVQUAL model is a good scale to use when measuring service quality in various specific industries. These contributions are important for PSSC, but they are mainly strategic and conceptual or lack operability in practice. PSSC participants prefer to have a certain and operable way to be servitised so that they can predict, and even assure their future expected benefits,

especially the financial consequences from their business.

Nowadays, the servitisation paradox drives academics and practitioners to consider the cost, revenue and profit of servitisation from the financial and accounting perspectives (Neely 2008; Kreye, Newnes, and Mey 2014). For a specific organisation to be servitised, this means that its business processes with high return on investment (ROI) potential affecting its servitisation should be identified; firstly wherein there is a need to calculate its ROI of servitisation through quantifying the value created and the cost incurred. Actually, this idea reflects the requirements of business process management (BPM) success (Skelta 2012).

According to Thrane (2007), the accounting system plays a central and crucially constitutive function in the establishment of any system/social changes within organisations. From this viewpoint, we suggest that it can be employed to measure the performance/value of a servitised organisation. Based on the value measurement method to the product cost plus a subjective marginal value that depends on the person's value system (Neap and Celik 1999), and the

performance of activity method used to identify the performance measures and metrics (Chan and Qi 2003a), a formula for quantifying the PSV of PSSC is presented. This formula combines the activity-based-costing (ABC) method used to quantifying the IPSV which means value is linear correlation to the related business process /activity cost, with the Delphi method (Okoli and Pawlowski 2004) used to calculate the EPSV. It is written as:

$$V_k = \sum_{i=1}^{M_k} \sum_{j=1}^{VA_{ij}} \alpha_{ij} C_{ij} + V_{sok} + V_{emk} + V_{epk} + V_{cok} + V_{enk} \quad (1)$$

Where,

V_k means the quantity of value co-created by Participant k in a PSSC system ($k = 1, 2, \dots, K$)

K denotes the number of PSSC participants

M_k denotes the number of business process subsystems of Participant k in PSSC

VA_{Mk} is the number of value activities of M_k business process subsystems of Participant k

α_{ij} is the ratio of the output to input during the value creation of VA_{ij} , it can be determined by the designer, manufacturer and sales price decision maker of the related product-service.

C_{ij} and $\alpha_{ij}C_{ij}$ denote the activity cost of VA_{ij} and the internal PSV created by VA_{ij} respectively

V_{sok} denotes the social value of EPSV provided by Participant k , and can be determined through market survey. It may be positively or negatively related to demographic, socio-economic and cultural (ethnic) groups.

V_{emk} denotes the emotional value of EPSV provided by Participant k , and can be determined through market and customer survey. For customer, emotional value may arise in a positive way like “loyalty, nostalgia, excitement” or in a negative way like “fear, anger and guilt”.

V_{epk} denotes the epistemic value of EPSV provided by Participant k , and can be determined through market survey and its service innovation degree. For example, customers who look for variety, novelty can accept a new product-service with a high price.

V_{cok} denotes the conditional value of EPSV provided by Participant k in a special environment. Generally, the consumer’s conception of conditional value is influenced by the external environment and cannot be known before a condition that will change the behavior arises. In some circumstances such as “celebrations, festivals and special days”, consumers may be aware of the conditional value that the product they buy will provide them.

V_{enk} denotes the environmental value of EPSV provided by Participant k .

Quantifying the IPSV here is a process based measurement. According to Davenport (1993), a process is defined as a structured and measured set of activities

designed to produce a specific output for a particular customer. The performance of each process is the aggregated results of the performance of all its lower hierarchy activities and sub-processes. Hence, accessing the activities performance can depict the effect of the corresponding process. In other words, measuring the higher hierarchy process performance is transformed into accessing the activities and processes performance in the lower hierarchies (Chan and Qi 2003a). For the EPSV, it is an order/customer-specific value type as it means different benefit /utility influenced by the factors of “customer, time, place and environment of every order”. Thus, we should firstly identify these factors when quantifying the EPSV. Here, we intend to use the Delphi method to calculate the EPSV as its uncertainty depends on the factors of “customer”, “time”, “place”, “condition”, and “circumstance”.

3.5. Modelling the business process system of PSSC using e³ alignment

The foundation of e³ alignment is a top-down process combining business strategy, business value processes, and an information system. It possesses two key features: 1) it is concerned with creating alignment between organisations operating in a value web of these organisations; 2) it takes strategic, value, process and information system perspectives on interaction between organisations (Pijpers, Gordijn and Akkermans 2009). Pijpers, Gordijn and Akkermans (2009) also claim that although in many cases all the four perspectives are considered relevant for inter-organisational alignment, they do not believe that all perspectives are always required. Observations from our case study suggested that stakeholders are often more concerned with a subset of these four perspectives, rather than all of them in practice. The main concern of our research was how to make the PSSC business process system feasible from the ROI perspective, and thus possibly avoiding the servitisation paradox. Hence, we mainly consider the value and process perspectives in e³ value modelling.

E³ value is firstly presented to describe and analyse the e-business model from the perspective of value, which helps define how the economic value is created and exchanged within a multi-participant network. The advantage of this approach is that it makes different participants have a common value proposition in a subjective sense, and also provides a visual, structured and quantitative approach to promote the value proposition to be understood in an objective sense.

Following the modelling procedures of e³ value (Gordijn and Akkermans 2001), a fundamental e³ value model of PSSC is built in Figure 1 which begins with the identification of service business process flow scenarios, and then the participants (actors) involved,

followed by the value activities, value objects, value ports, value interfaces, and value exchanges, which explain how the actors exchange values through the paths to the service scenarios.

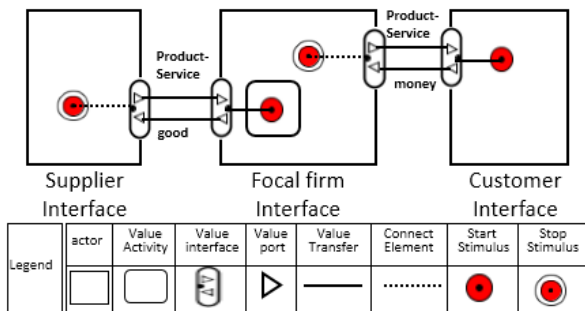


Figure 1. A generic e³value model for PSSC

In this generic conceptual model PSSC participants are the cluster of three core interfaces. The customer interface gets product-service from a focal firm's interface, and the focal firm interface gets the corresponding return through providing the product-service. The focal firm and suppliers obtain their compensation from the mutual exchanges between them. The start stimulus is usually from the customer interface, while the stop stimulus ends in the final product-service provider interface. The connecting dotted element shows the primary service scenario path, which represents the dependence relationship among the internal value interfaces of the three core interfaces.

Figure 1 indicates that this model can not only capture customer needs accurately, but also locate all the value-added activities, and their supporting activities across PSSC. Consequently, a "pull value chain" like "Pull Production" (Spearman and Zazanis 1992) is formed. Furthermore, through this model the metrics of every value activity, and all the value-added points can be verified and measured individually, and finally get the profitability level of every participant and the whole PSSC.

The emphasis of this model is to define the value added activities and processes, determine the allocation of value activities, and the amount of PSV created by each participant. It shows where and how PSSC acts and creates value clearly.

3.6. The value oriented organising business process method for PSSC

With reference to the SCOR model (SCC 2010), the essential principles to identify, measure, reorganise and improve supply chain processes with a cyclical approach includes: 1) capturing the configuration of a supply chain; 2) measuring the performance of the supply chain and comparing against internal and external industry goals; and 3) re-aligning supply chain

processes and best practices to fulfil unachieved or changing business objectives. These principles working together provides a solid framework that links business processes, performance metrics and best practices into a unified structure, which can make it possible for organisations to quickly determine and compare the performance of supply chain and related operations within their organisation and against other organisations. Accenture (2013) enhanced this point by stating that process modelling and optimisation with good tool support had been the dominating practice within 95 respondent BPM teams which are largely from Fortune 500 organisations.

With reference to the business process based cyclical and optimal mechanism of the SCOR model, and the Skelta BPM solution of Invensys Systems Inc. (Skelta 2012), a value oriented organizing business process method for PSSC is taking shape with inputs from the implementation and validation activities of our case study with Company A. More specific models (see Figure 2 & Figure 3) could then be developed to consistently integrate the visual, e³value modelling tool, and the proposed PSV quantifying method. Therein, we employ the e³value to map and visualise the configuration, and structure the business processes of PSSC, and the proposed value quantifying method to measure and analyse the business processes' performance, and compare against the best practice respectively. This method comprises the following main steps.

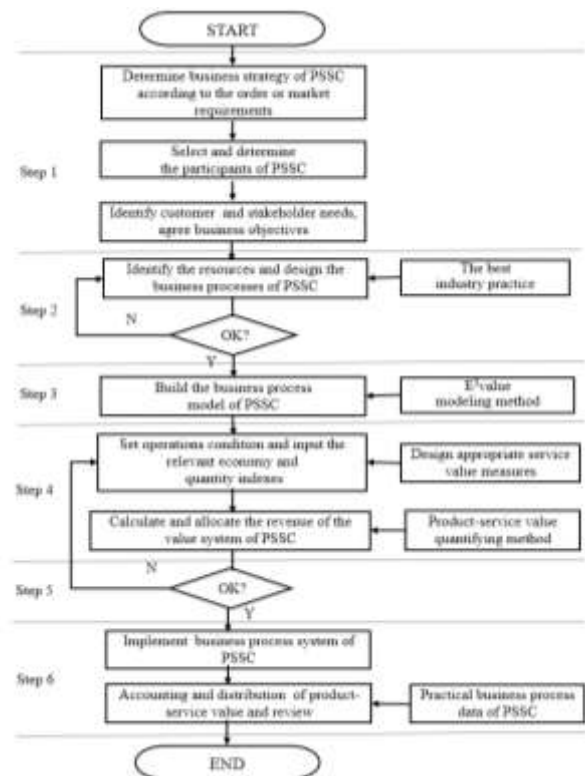


Figure 2. PSSC business processes

Step 1: For a PSSC to be built, the first task is to determine its business strategy. Then, according to each specific order/customer or market requirement, select and determine the service providers and service integrator to compose a dynamic PSSC, and identify each participant's value proposition, and make everyone's role clear among the value chain. Finally, create a coherent set of top-level business objectives through developing the business objectives from the needs of customers and stakeholders. Especially, according to the definitions of the detailed IPSV/EPVS types in Table 1, customer's individual preferences and the related situation/circumstance should also be considered to make more personalized product-service for co-creating more PSV hereafter.

Step 2: Referring to the related best practices, design the business process system based on the customer's individual preferences and the related situation/circumstance which includes the value activities, value creators and receivers, value exchange conditions and their quantitative relations. After this, review and evaluate this business system preliminarily. If it can't satisfy the top-level business objectives, then repeat step 2; if feasible, go to step 3.

Step 3: Build the hierarchical business process model of PSSC using the value element deconstruction method of e³value step by step. The deconstruction takes the following steps.

First, deconstruct the large-grained value activities after identifying all of the value added activities, and their relevant actors of every business process tier into smaller ones. Second, deconstruct the value objects and parts of the above deconstructed activities into smaller ones as well to find smaller portions, which can be requested or offered by an actor. Third, de-bundle the value interfaces and offerings into the value interfaces and offerings of a smaller number of value ports. Repeat the above steps until the smallest activities are derived. Finally, reassemble the new value model, by assigning the newly deconstructed value activities to actors.

Step 4: Initialize the business process system of PSSC. First, referring to the best practices and Table 1, identify the appropriate PSSC value indicators, and set the operating conditions of the business scenarios of the PSSC model. Then, input the related parameters (input, expense, etc.) to the business model, simulate the model and calculate the values created by each participant and the whole PSSC, and the revenues of every PSSC participant using the equation (1) and e³value method. The yield results can quantitatively show whether the business process system can achieve the business objectives agreed.

Step 5: If the results of Step 4 does not meet the business objectives, then adjust the model variables such as the actors, the value exchange conditions and

quantities, and the drive force of business operations, etc. and repeat step 4; If the results cannot meet the requirements after several times, then go to step 2; If they can, go to step 6.

Step 6: Implement the business process system and after fulfilling every order, the total value and revenue needs to be calculated, and the yield should be distributed to every participant of the PSSC. Finally, review the related experience and problems that have appeared for further improvement.

From these steps, this method is a value-oriented organising business process for PSSC considering all stakeholders' needs, a top-down approach and a bottom-up execution with feedback and a self-optimisation mechanism.

4. Case Study

This case study was conducted to validate the theoretical findings set out in previous sections, i.e. to validate and refine the conceptual model, and at the same provide a demonstration for how the business processes of PSSC can be effectively organised to overcome the servitisation paradox. The case study can also reveal where and how the values of PSSC are created, delivered, visualised, quantified and assessed by using the proposed method.

4.1. *The case company and its appropriateness for our research*

Company A is a commercial and residential carpet manufacturer with a long history of manufacturing capital goods involving both a complex experience and technical knowledge. It operates in a global market and has factories, suppliers and sales offices in different continents. Historically, Company A has mainly focused on the traditional R&D, manufacturing and sales of carpets. Accompanied with increasing competition and a service-dominant economy, it faced the challenge to build a novel business model for its carpet supply chain in order to sustain and develop its business. To keep the leading position, Company A intended to firstly compete in the carpet industry on the basis of the provision of services around its products in order to meet the increasingly customised and higher expectations from the market. Based on the systematic analysis of a "servitisation paradox", and some successful and failed practices in other industries around the Europe and other countries, Company A decided to rely on intelligence inside and outside to implement servitisation. One of the co-authors of this article was engaged to facilitate adopting servitisation across their supply chain.

At present, the servitisation of Company A and its partners have been improved gradually, and they have

also kept obtaining marketing, financial and strategic benefits through this transformation. The proportion of revenues that generate from services in Company A is about 25% while its profit margin has increased by 5%, and the competitiveness and customer loyalty have also been improved, which has subsequently led to an increased market share in later years.

4.2. An illustrative example

Considering the financial consequences that a servitisation paradox might result from analysing the empirical evidence on the range and extent of servitisation of 10,028 firms incorporated in 25 different countries (Neely 2008), Company A firstly identified what the good potentials were to create and provide more value for the customer, which included the business processes of design, sampling, installation, aftercare & maintenance, and additional offerings such as project management for customer orders. These business processes were viewed as the emphasis needed for servitising Company A and its partners. Secondly, a servitisation solution to this carpet supply chain was proposed, which was how to gradually add more value-added service elements to the identified business processes. For example, the novel design services were developed for various customer groups, order types, order sizes with different requirements. There were also various levels of installation services for customers, and for the maintenance they established a well-planned, regular maintenance and care program to ensure that their carpet performs to its specification and keeps its good looks for longer, etc. Table 2 shows the improved or added service business types and their related activities. Finally, when a new carpet product-service order arose, then a need would exist to organise a business process system with the best ROI for this order. Therefore, the purpose of using this method is not only to organise the business process system but also to demonstrate its validity and profitability for every order from various customers. To validate the method set out in this paper, we select nine typical residential and commercial orders completed below (see Table 3) by Company A and its partners in recent years which processes can also show how Company A use this method to support their servitisation. The implementation processes are as follows.

To fulfil the nine orders using this method, the data were firstly collected from Company A and its partners, customers and three invited professionals who were all very familiar with the carpet industry, the cost-volume-profit data of carpet production, and could represent all the stakeholders of the carpet supply chain. The following business process modelling and PSV calculation was also supported by them. Furthermore,

the cost data about the IPSV of equation (1) were collected directly from Company A, its partners and customer surveys while the EPSV was determined by the three professionals through interviews and the Delphi method (Okoli and Pawlowski 2004).

To avoid potential bias in the process of data collection and analysis, these nine orders were selected from five different sectors of hospitality, gaming, leisure, public space and residence. Considering the factors of cost-efficiency and comparability, they were classified into three types of small, medium and large size orders according to their contract sizes. Especially, without affecting this study, the original data was processed technically because it is sensitive. The decision processes for the nine orders can be described below.

Step 1: According to the individual requirement of the classified orders and every customer's preferences (see Table 3), Company A, the supply chain service integrator first determines their relevant business strategies and business emphasis; then evaluate and select the qualified participants for each order, which included the service providers of raw material, design, manufacturing, delivery, installation, aftercare and maintenance inside and outside. Finally, the business objectives of the carpet supply chain and its participants for each order are also set after negotiating among the participants. Then, identify the service resources and design the business processes for all the selected participants to establish the PSSC systems for each order respectively referring to the related best practice.

Step 2: Based on the business processes designed, use the e^3 value to model nine carpet supply chain systems for the nine orders. In the unified e^3 value model (see Figure 3), the value actors and their business processes/ activities related to Company A are shown respectively in Table 4.

Step 3: In accordance with the cost metrics of the SCOR model (SCC 2010) and the costing information collected from the supply chain participants, Table 4 and Table 5 show the cost items, and their expected cost of all the business process subsystems of Company A, and its installation, aftercare and maintenance partners in each supply chain system which contribute to the above orders respectively. In order to make the subsequent comparison and analysis, the historical statistic cost data of the similar orders of Company A and its partners before servitisation are also provided in Table 5.

Step 4: Calculate the PSV created by the supply chain systems for the nine orders using the equation (1).

Step 4.1: The invited three professionals determine the α_i values of every participant's business process subsystems (see Table 6) using the Expert Evaluation Method. Note that α_i replaces α_{ij} which is the value coefficient of each supply chain participant's business process subsystem.

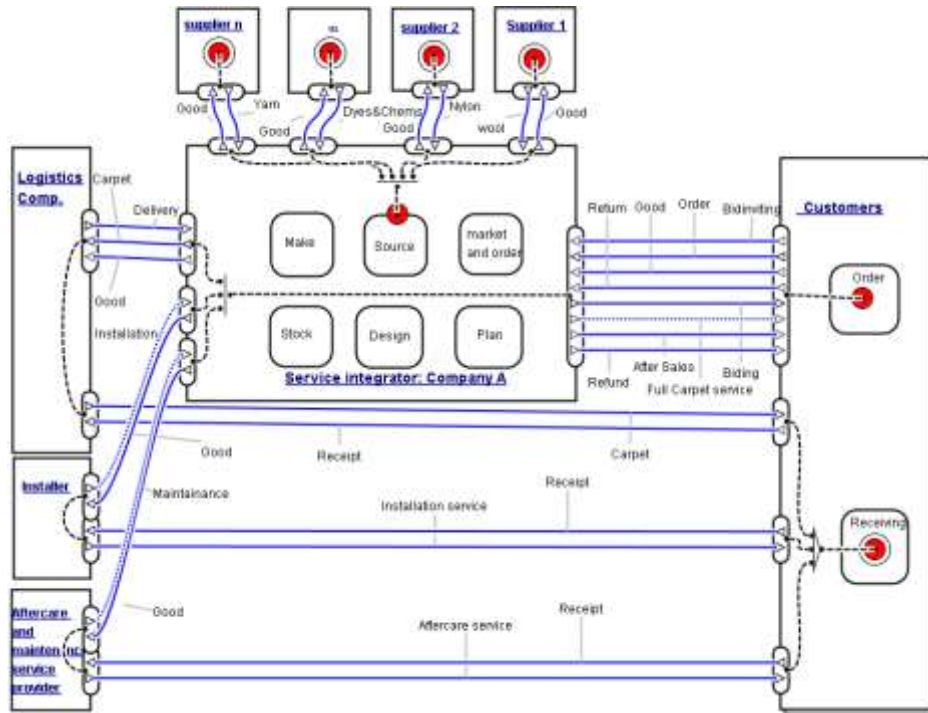


Figure 3. The specific business process system of Company A

Step 4.2: Calculate the expected internal value created for each order using the equation (1) (see Table 7).

Step 4.3: The professionals use the Delphi method to obtain the expected external values of every order (see Table 7). Here, as each order type's customers have different preferences, the related EPSV varies from one order type to another.

Step 4.4: Calculate the expected total value created of the nine orders in Table 4 (see Table 7). Likewise, the value data of the similar and historical orders are also provided in Table 7.

Step 5: Calculate the expected gross profits of each order (see Table 8) and which comply with the expected business objectives of all participants.

It is also noteworthy that the specific model for this case study (see Figure 3) was developed gradually with involvement of various departments of Company A as well as its suppliers and partners. The company had to cope with some critical challenges before it could really use this model to guide the transformation of servitisation. For example, there was some significant deviation between the expected outcomes and the reality. That was a fatal problem because it determined whether or not the PSSC system could be implemented in practice. The company formed a dedicated team to find out why the deviation happened. Main reasons include: 1) the inaccurate cost information of business processes and business activities of PSSC; 2) insufficient understanding about the difference of value under various customer's preference or situations; and 3)

inexperienced employees who made obvious mistakes in identifying and calculating the critical figures of EPSV. With help of the researchers, the company developed some effective tools and training programmes to address these issues.

4.3. Results analysis

For the cost analysis, Table 5 shows that the ratios of the nine orders' predicted costs to their similar historical costs vary a lot, where the orders with the small order size have the biggest ratios, and the orders with the large order size hold the smallest ratios respectively.

Table 7 and Table 8 show that the predicted revenues are roughly in line with the actual figures and each order contributes more or less gross profit to the related supply chain respectively. Compared with the Order Type 1&2, a greater ratio of the current revenue to the historical revenue has been achieved by Order Type 3 with the most services. However, this ratio of Order Type 1 is similar to the Order Type 2 despite the fact that it has fewer services.

From Table 7 and Table 3, the ratios of "ESPV to Total value" of Order Type 1, Order Type 2 and Order Type 3 are about 3%, 4% and 6% respectively. This suggests some positive correlation between the ESPV and the number of the emphasized business service of every order type. This implication was verified in a later interview with a marketing manager of Company A. Her explanation about this phenomenon was that the more preferences/personalised requirements the customers

have, the more business services should be provided, the higher price they would offer and thus more EPSV would be created.

In Table 9, the gross profit margins of Orders 1&4&7 with a small size are lower than the similar historical ones where the differences are -6.6%, -4.1% and -1.2% respectively, whilst the Order 2&5&8 with a medium size and Order 3&6&9 with a large size make greater profit margins where the differences are 3.4%, 0.3%, 6.3%, 3.8%, 3% and 5.7%.

From Table 5 to Table 9, we can also calculate the average contributions to the “IPSV minus Total cost” of all the business process subsystems in the nine orders, the contribution rates of the “market and order, design, plan, source, make, deliver, installation, aftercare and maintenance” subsystems are about 9.8%, 34.4%, 2.9%, 0, 30.9%, 0, 2.2% and 19.7%.

Based on the above figures, the following analysis had also been made available to the company.

a) All the PSSC participants need to invest/cost more for each order than ever before.

b) Servitisation could lead to more profit and revenues such as the Orders 2,3,5,6,8&9 with a large order size, while it could also make less profit such as the Orders 1,4&7 with small order size. Hence, a servitisation paradox phenomenon occurred because a high return couldn't be assured by high cost or investment, and order size had significant impact on the final profit which indicates the economy of scale. However, “the larger order size, the more profit” was not always proper either because of the diminishing returns. For instance, Order 8 with a medium size made more profit margin than Order 9 with a large size.

c) Various order types/customers had different focuses/preferences under different situations, this would drive personalized business processes for these individuals. Normally, more personalized business processes would generate more value. However, different servitised business processes generated different returns which might vary more or less. For example, Orders 7-9 of Order Type 3 with the emphasized design, installation, aftercare and maintenance services had more profit margins than the corresponding orders of Order Types 1&2 with less services emphasized. However, the orders of Order Type 2 with the emphasized design, and installation services had nearly the same profit margins as the orders of Order Type 1. These might indicate that aftercare and maintenance service could make more profit than an installation service while an installation service may contribute less. Furthermore, the design service was also a high value-added business process from Orders 2&3 of Order Type 1 with only the design service emphasized. As for this example, the business processes of design, make, aftercare and maintenance, and market

and order were the Top 4 value-added contributors, which suggested the servitisation of Company A and its partners were focused on the business processes of these four areas rather than the traditional “make” operations. Generally speaking, servitisation would require an organisation to consider some high priority issues including the level of investment/cost implications, the economies of scale and the diminishing returns of the servitising business processes, and the business processes with high value-added potential.

4.4. Managerial implications

Through implementing this method in the case company, we found that this method provided an overall framework linking together independent business entities, business processes, metrics and best practices into a unified, visualized and hierarchical structure, which can facilitate establishing a supply chain by modelling common business processes and quantifying their value across multiple organisations. The method can also support PSSC's improvement by aiding the capture of an “as-is” current state from which the desired “to-be” future state can be derived. From this perspective, it is consistent with the basic principles of the SCOR model (SCC 2010).

Figure 4 presents the servitisation roadmap of this case company from the viewpoint of business process transformation. It shows how a traditional product supply chain company moves towards a PSSC gradually through small quantitative gains to qualitative business transformations. For Company A and its partners, this method happened to provide a business process operations technique to organise and manage the above moving.

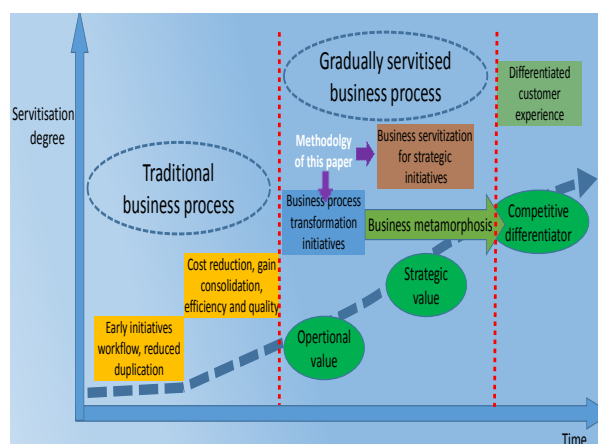


Figure 4. The PSSC transformation roadmap of Company A

We found that this method was useful in helping managers to operate their PSSCs effectively. It contains a synthetic value interpretation incorporating requirements from both the customer and its product-

service provider, which reflects the nature of value co-creation in PSSC, as well as a unified value calculation method. This method combined with the e³value modelling techniques, can effectively identify which business processes/activities are directly related to customer value in a particular situation. By speeding up data collection, these can make it less time consuming for managers to make effective decisions. Further, through building and evaluating the business process model of a PSSC based on a rigorous method, it can provide optimised solutions to basic questions such as: a) how to visually organise the business process system of the PSSC? b) how to identify the revenue and value generators; where and how is the value created, delivered, decomposed, exchanged, and consumed qualitatively and hierarchically in the PSSC? c) how to analyse alternative configurations and process layouts and quickly initiate corrective actions for the PSSC? and d) how to quantify the revenue and value to evaluate the potential profitability of the PSSC to avert the servitisation paradox? These make it possible for an organisation to quickly assess and determine to what extent it can be servitised, and if it is being servitised, how to servitise it, and what does the servitisation change through the simulation analysis? In brief, this method will benefit an organisation in the following aspects:

- An understanding of PSSC and its PSV from the perspective of customer, supplier and business process
- Effective modelling and organizing business processes of PSSC
- Rapid calculation and assessment of PSSC business process performance
- Clear identification of PSSC value creation process and PSSC performance gaps
- Effective and efficient PSSC network redesign and optimization
- Alignment of PSSC member value creation with strategic objective
- A detailed game plan for launching new businesses and products

5. Conclusion

In this paper we introduced a value oriented method for organising business processes for PSSC. We would like to argue that the implementation of a servitisation project requires not only the strategic changes, but also the effective renovation and reorganisation of business processes in an organisation from the perspective of value. Our research findings and the implementation case revealed a recurring pattern to organise servitising organisations with an averting servitisation paradox.

We proposed a structured method for PSSC and PSV

to identify changes required in the transformation of servitisation. An important contribution of this method is to interpret value for PSSC in a view to measuring the PSSC performance quantitatively. By echoing Giaglis et al. (1999), such a method that enables the modelling of business processes, the evaluation of their performance, experimenting with alternative configurations and process layouts, and comparisons between diverse proposals for change is highly suitable for organisational design and supply chain management. As validated with an in-depth case study, this model can help organisations to organise and optimise their PSSC through visualising the key processes, identifying the main objectives, and aligning their internal and external activities. Moreover, this method introduces “the value perspective” as its distinguishing feature. This provides a novel approach to business process and IT architectural modelling for the current business environment.

We would also like to discuss the limitations of this method by now. The method works well for PSSC in a relatively stable environment. It might be difficult to measure the value created probabilistically if the PSSC business processes change rapidly. At the same time, the quantifying measures for the internal and external PSV are based on the Activity Based Costing, and depend on inputs from the experts, which to some extent are relatively subjective at the operational level. It might be a challenging task to access experts who have a good understanding about PSSC business processes and their cost-volume-profit relations in practice. There is therefore a need to develop an operational weighting/scoring system to guide managers on how to develop and adopt proper indicators for value. At last but not the least, we recognised that our findings might be limited by the use of a single case study. This should not be seen as a major flaw of our research, because the main objective was to initiating this interesting research area by developing the value-based modelling method for PSSC, instead of generalising the findings. We would however like to call for further studies to further develop and test the method in various operations contexts, which may lead to more robust techniques that can be directly used by managers to enhance the performance of PSSC in a particular situation.

Acknowledgement

We would like to acknowledge support from the National Natural Science Foundation of China (NSFC) Project No. 71171066 & 71571056, and the Seventh Framework Programme of the European Union through Marie Curie Actions IRSES Europe-China High Value Engineering Network (EC-HVEN), Grant No. PIRSES-GA-2011-295130.

Table 2. The improved or added service business activities of the carpet supply chain system

Product-service business type	Product-service business activities or services
Design service	Global network of design studios, innovative online design studio and the industry's largest floor covering design archives
Sampling	Full custom sampling service, bespoke colour development, design print outs and woven trials
Installation	Recommended method of installation and use of underlay, full installation service with offering advice, technical supervision, on-site advice, etc. in conjunction with global network of installation partners
Aftercare	Recommended care methods and programs for various carpets under different environments
Maintenance	Recommended cleaning and maintenance programs for various carpets under different environments
Project management	Entire process management from start to finish customer project by professionals

Table 3. Some typical carpet product-service orders of Company A

Order type	Small order size	Medium order size	Large order size
Order Type 1: Design service emphasized	Order 1: Order size: 1,500 m ² Application: Residential	Order 2: Order size: 10000m ² Application: Public spaces	Order 3: Order size: 32000m ² Application: Marine
Order Type 2: Design and installation services emphasized	Order 4: Order size: 2500m ² Application: Leisure	Order 5: Order size: 9000m ² Application: Hospitality	Order 6: Order size: 20000m ² Application: Airport
Order Type 3: Design, installation, aftercare and maintenance services emphasized	Order 7: Order size: 4000 m ² Application: Healthcare	Order 8: Order size: 18000m ² Application: Public spaces	Order 9: Order size: 40000m ² Application: Airport

Table 4. The value activity (VA) sets of Company A (actor) in the supply chain system

Business process subsystem	VA Set 1	VA Set 2	VA Set 3	VA Set 4	VA Set 5	VA Set 6	VA Set 7	VA Set 8
Market and order	market requirements	business opportunity evaluation	capacity & lead time estimation	costing	bidding and negotiation	negotiate & receive contract	order fulfillment	after sales
Design Plan	conceptual design master plan	preliminary design design plan	detailed design source plan	redesign make plan	quality plan	risk mitigation plan	deliver plan	after sales plan
Source	instructions to source	sub-contractor selection	Receive, identify, transfer and store	authorize payment				
Make	finalizing production engineering	production schedule	issue sourced & in-process material	produce and test	package	store	releasing carpet to deliver	
Delivery installation	select carrier developing installation method	deliver outsourcing train installers	delivery installer selection	authorize payment installation	delivery evaluation offering advice on installation	technical supervision, on site advice		
Aftercare and maintenance	developing aftercare and maintenance program	training partners	partners selection	aftercare and maintenance	offer advice on care and maintenance	technical supervision, on site advice		

Table 5. The predicted cost of the VAs performed for the orders in Table 4

Business Process Subsystem	The cost of the business process subsystems								
	Order 1	Order 2	Order 3	Order 4	Order 5	Order 6	Order 7	Order 8	Order 9
Market and order	20000	32200	78840	18500	31300	53280	36000	100440	174000
Design	50000	64400	157680	29600	50080	79920	44000	117180	174000
Plan	12000	12880	59130	11100	18780	39960	20000	50220	104400
Source	40000	289800	748980	46250	250400	559440	72000	502200	1113600
Make	54000	225400	847530	55500	219100	506160	96000	502200	939600
Deliver management	24000	32200	78840	12950	31300	53280	32000	66960	139200
Installation	N/A	N/A	N/A	11100	25040	39960	16000	50220	104400
Aftercare and maintenance	N/A	N/A	N/A	N/A	N/A	N/A	84000	284580	730800
Total cost	200000	644000	1971000	185000	626000	1332000	400000	1674000	3480000
The similar historical cost	170000	590000	1870000	153000	563000	1265000	300000	1339000	2993000
The ratio of the current orders' cost and the similar historical cost	118%	109%	105%	121%	111%	105%	133%	125%	116%

Table 6. The α_i value of the business process subsystems

Business Process Subsystem	The value of α_i of every process subsystem		
	Order type 1	Order type 2	Order type 3
Market and order	1.10	1.10	1.10
Design	1.25	1.25	1.25
Plan	1.05	1.05	1.05
Source	1.00	1.00	1.00
Make	1.05	1.05	1.05
Deliver management	1.00	1.00	1.00
Installation	N/A	1.05	1.05
Aftercare and maintenance	N/A	N/A	1.10

Table 7. The predicted PSV created for each order

Order number	Order 1	Order 2	Order 3	Order 4	Order 5	Order 6	Order 7	Order 8	Order 9
The IPSV	217800	688114	2063637	198135	654796	1386612	429600	1771929	3671400
The EPSVExternal value	6534	20643	61909	7925	26192	55464	25776	106316	220284
Total PSV	224334	708757	2125546	206060	680988	1442076	455376	1878245	3891684
The predicted revenue	224334	815071	2380612	212242	783136	1615126	478145	2253894	4475437
The actual revenue	222000	795000	2400000	210000	780000	1650000	475000	2200000	4500000
The similar historical order's revenue	200000	708000	2206000	180000	700000	1530000	360000	1675000	3700000
The ratio of the current order's actual revenue to the similar historical order's revenue	111%	112%	109%	117%	111%	108%	132%	131%	122%

Table 8. The predicted gross profits of each order

Order number	Order 1	Order 2	Order 3	Order 4	Order 5	Order 6	Order 7	Order 8	Order 9
Gross profit	22000	151000	429000	25000	154000	318000	75000	526000	1020000

Table 9. The gross profit margin of the current orders and the similar historical orders

Order	Order 1	Order 2	Order 3	Order 4	Order 5	Order 6	Order 7	Order 8	Order 9
The current orders	11.0%	23.4%	21.8%	13.5%	24.6%	23.9%	18.8%	31.4%	29.3%
The historical orders	17.6%	20.0%	18.0%	17.6%	24.3%	20.9%	20.0%	25.1%	23.6%

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