

# STRATEGY FRAMEWORK DEVELOPMENT BASED ON BUSINESS COMMERCIAL INTEGRATING CO-CREATION PROCESS TO GUIDE PRODUCT-SERVICE SYSTEMS' TRANSITION

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**Abstract** Product-Service System (PSS) is considered as a promising solution for manufacturing industry to address environmental and economic issues simultaneously. Despite the potential benefit, PSS uptake across industries is hardly found. This research aims to draw current state of manufacturing industry upon theoretical framework of PSS typology to get insights of the gap in between. The study exhibits PSS level assessment indicated by key character identified from the various literature of PSS typology. It also introduces co-creation process as a strategy to increase system capability within PSS framework. Manufacturing companies are selected from various source of literature and article in PSS discussion to exercise PSS assessment. The evaluation of PSS current practice reveals that commercial based transaction need to tell about B2B and B2C play a significant role to determine the suitable development strategy for PSS transition. Furthermore, the type of business commercial also determines the customer involvement level in co-creation process. A framework to guide PSS transition based on the business commercial is established, comprehends the type of value proposition, suitable business strategy, network configuration, and co-creation level.

**Keywords:** Product-Service Systems, Co-creation, Framework, B2B, B2C

## 1. Introduction

Research agreed that manufacturing industry creates considerable environmental impact while at the same time has a significant role in society and economic development. Energy consumption of industrial sector range to 30% - 70% [1], not to mention the emission result from energy use during production stage[2]. Despite the environmental impact, the important role of industry in economic development is undeniable. In respond to those issues, a survey reported that since 2007 CEOs has started to align sustainability concept into their business activity [3]. Various approach and method have been investigated and developed to address these issues. However, it appears that the proposed methods provide only parts of the solutions. Each of solution has its strength and also limitations to minimize environmental impact.

However, when those methods are integrated into a system, sub-optimization might occur and may reduce the method's efficiency in addressing environmental issues [4]). In a brief research argue that previous approach is considered not sufficient to solve environmental problems [4]–[6]. Additionally, existing industries are challenged with more sophisticated demand related to energy efficiency and material flows [4], hence requires holistic solution on the system level. Under this circumstance, this study introduces Product-Service System (PSS), offering the solution for multi-dimensional challenged faced by industry (e.g. [7], [8]).

PSS is distinct from the idea of cleaner production, green production or any other concept that related to process and design engineering [5]. PSS focus on reducing material flows in production and consumption, and as the consequences, PSS attempt to increase resource productivity by providing products and services to meet consumer needs [4], [9], [10]. Therefore, is considered to be a promising business model

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for manufacturing industry to address economic and environmental issues simultaneously.

Despite the potential advantage of PSS, the uptake of the system in the industry is scarcely found. Several barriers have been identified in regard to PSS implementation. Studies mentioned that existing consumer behavior, doubtful of eco-benefit and company readiness deter the system implementation [4], [8], [11]. While the system uptake by industry is mentioned very rare, in fact, existing manufacturing industry have included service as their value proposition to support their product sales. Service has always been the part of the business activity in the industry. Why the author discuss about the service aspect for the manufacturing industry?

Those fact is manifest in various research in PSS typology [12]–[14] in which includes service-support-product oriented business model as one of the PSS categories. This resulting bias regarding the PSS definition and irrelevant with the purpose of PSS itself. PSS suppose to lead manufacturing industry into more service oriented. A manufacturing company involving the tangible assets and output should be able to create value in the form of service to satisfy customer.

Furthermore, several barriers have been identified in regard to PSS implementation. Studies mentioned that existing consumer behavior, doubtful of eco-benefit and company readiness deter the system implementation [4], [8], [11]. Additionally, research discusses tools and method to support industrial transition are hardly found [15]–[17]. On the other hand, research in value co-creation is emerging, reveals some potentiality to be adopted PSS to support its transition at the operational level.

To improve PSS uptake by industry, evaluating the existing practice and identify the gap to support the PSS transition toward product-support-service oriented becomes necessary. This research aims to assess the current state of PSS uptake by existing manufacturing industry. Despite the ambiguity, this research utilizes PSS typology to describe the PSS transition from existing into expecting PSS practice and accordingly assess the practice of manufacturing company based on the key character of each type. Following the assessment, a strategy is proposed to bridge the transition from existing into expected PSS implementation. Relevant manufacturing

companies are chosen to represent the shift on PSS.

In detail, this research objective includes developing PSS transition assessment tool based on PSS typology theory, evaluating the current state of PSS practice on manufacturing industry utilizing PSS transition assessment tools, and eventually, designing a framework strategy to guide business transition for PSS implementation by introducing co-creation process.

Based on the literature study, this research contributes to build a framework strategy development for PSS business transition, introducing co-creation process to increase the system capability. The output of this research can be utilized to determine a suitable strategy for manufacturing industry to evolve into advanced PSS implementation.

This paper is structured as follows: Section 2 presents the ground theories and literature to get the insight of required improvement and suitable approach to leverage PSS adoption on manufacturing industry. It starts with PSS conceptual theory, including PSS character that differs with the conventional business model, and PSS typology from various approaches. The literature on co-creation process is discussed, leading to a critical analysis of its potential correlation with PSS. In Section 3, an outline of PSS transition assessment tool is presented, a new instrument to evaluate the current state of manufacturing companies on implementing PSS compare to expected PSS practice. To demonstrate the instrument, measurement of various manufacturing companies is conducted. The companies are selected from previous literature in the field of PSS and related topic. This section also introduces and analyze co-creation process, and investigate its potential alignment with PSS framework. The underpinning theory is established to build a strong argument about the potential of Co-creation process adoption into PSS framework. Section 4 discusses the relevance and the contribution of PSS transition matrix and the output for the advancement of PSS concept to achieve its goals of the PSS literature. Finally, Section 5 summarizes the main conclusion of this paper.

## 2. Ground Theory in Product-Service Systems

## and Value Co-creation

### 2.1. PSS: Overview

#### 2.1.1. Definition and PSS Entities

The idea of PSS is to advance conventional manufacturing industry's business model that focuses on product sales into more service provision oriented. Environmental consideration, as well as economic sustainability, encourage the rise of PSS concept. The ultimate goals are to reduce resource consumption due to rebound effect while at the same time achieve customer satisfaction [4], [18]. Studies in PSS stated that instead of selling goods, a business that adopts PSS will provide services and utilities for consumers through the use of product-service combined to achieve results expected by costumers [4], [5], [11].

Other studies suggest various definitions of PSS (such as [6], [18], [19]. Those definitions share similar component consist of the entities of the system (i.e. product, service, infrastructure, network), and the purpose of the system (summarized as to satisfy the customer and lower environmental impact). Unfortunately, these definitions consist ambiguity that may lead to a different perspective of PSS.

Despite the definition that involves product and service within a system, it is necessary to understand that PSS is addressed for manufacturing and production system. PSS focuses on increasing resource productivity in production system through alternative scenario product use, and therefore, reduce resource consumption. To close the material cycle from shifting ownership since consumers do not necessarily own or buy goods to fulfill their needs is also the main purpose of PSS practice (e.g. [4], [5]. Accordingly, looking up on PSS definition as a guide for PSS development framework, it is critical to highlight the objectives of PSS to differ with the conventional industrial system (both production system and service system). Focus on the entity of PSS (combined product-service), while overlooking other entities and objectives may result misleading in PSS development.

#### 2.1.2. PSS Typology

The widely used PSS category within literature is introduced by Tukker [13] that classified PSS into three types: 1) Product-oriented; 2) Service-oriented; 3) Result-oriented Ostaeen et al.[14] argued that the PSS category by Tukker fail to capture the complexity of PSS

example found in practice. Hence his study refined the PSS typology based on revenue mechanism, distinguished PSS into four types include:

- 1) Input-Based revenue mechanism;
- 2) Availability-Based revenue mechanism;
- 3) Usage-Based revenue mechanism;
- 4) Performance-Based revenue mechanism.

Another study in PSS typology classifies PSS based on the business model [12]. This study refined previous PSS typology and classified based on the business model, attempting to help the company to have better understanding on the shifting toward a service-oriented business model. This study distinguished PSS into two major categories, ownership-oriented, and service-oriented, and divided each category into subcategories associated with revenue mechanism and value proposition.

The ambiguity of PSS definition is reflected in major discussion in PSS typology. To include product-oriented into PSS type without further concern to PSS objectives potentially lead to bias on designing PSS business model. Furthermore, discussion in PSS typology mostly focuses only on the combination of product and service, disregarding the state of internal system associated with network and infrastructure. Identify the internal condition of each type of combined product-service benefiting in guiding PSS transition. Accordingly, this study attempts to get insight from above mentioned PSS typology concept to describe the transition of PSS implementation, and interpret it into a measurement tool to evaluate the current state of manufacturing practice with concern to PSS objectives. This study will incorporate discussion related to network and infrastructure of the system to support the transition. The result will reveal the necessary improvement for industry to move into the service-oriented business model.

#### 2.1.3. Networks and Infrastructure

Looking up to PSS definition, network and infrastructure are frequently mentioned in the literature. Morelli (2006) emphasizes technological knowledge embedded in equipment and cultural aspect of participant actors that influence system development in PSS design activity. Other studies suggest infrastructure, partnership and information are consider to have a strong influence for

operational excellence of PSS [20]–[22]. The literature review lead to the identification of three factors necessary for PSS: infrastructure and network. This manifest that internal process capability strongly depends on infrastructure and network to extend the process capability to the desired level. This study focuses on comprehending the role of infrastructure and network and the processing mechanism in improving PSS implementation.

#### **2.1.4. PSS features**

Throughout literature review, several features have been identified as PSS characters [4], [7], [10] as described below.

##### **a. Shifting of role and ownership**

In contrast to the current paradigm, despite selling goods, PSS focus on providing service rather than ownership by renting or leasing it [7], [23]. Other suggest that it focuses on how to fulfill customer needs and create customer value [24]. Within this system, customers are released from the obligation of product ownership to meet their needs. This shifting is beneficial for the consumer because it will reduce initial investment as they purchase the product. Shifting of ownership leads to relationship changing between customer and company. Previously, after purchasing, customer fully responsible for the product through the whole life cycle. Following the property changing, the interaction between customer and business becomes more intensive, since the transaction may occur anytime during product life cycle. Customers become more engage in product-related decision-making together with the company (e.g. Cavalieri & Pezzotta, 2012; Vezzoli et al., 2015; Williams, 2006). This feature support previous argumentation in PSS typology, that product-oriented business model could be irrelevant with PSS framework, and therefore, this study highlights the shifting ownership in PSS which mean PSS within the service-oriented spectrum.

##### **b. Extended material management**

For business, the shifting of role and ownership in PSS provides an opportunity to have more control over their product life cycle. Regardless, the definition of product life cycle varies across the literature. For the purpose of the study, the author refers product life cycle definition by Sundin (2009) as “the progress of a product from raw material, through production and use, to its final disposal” as illustrated in figure 1.

In PSS, ideally product ownership belongs to the company. Hence, the potentiality to create value for company together with the customer arises within the whole lifecycle. Furthermore, under this system, product and material take-back rate is expected to increase significantly. Closed loop material become attainable under PSS framework.

#### **2.1.5. Benefit and Barriers**

Various studies have been conducted presenting about the benefit and barriers of PSS [4], [11], [15], [25]. Literatures commonly categorized the PSS benefit based on the stakeholder, including environmental benefit. Table 1 presents PSS benefit summarized from various literature.

Regarding barriers to implementation, the discussion in this feature evolves around consumer readiness, industry readiness, and hesitations in benefit of the system. Studies argued that consumer related barriers refer to the necessity of cultural shifting in consumer behavior. Several mentioned that consumers seem to be less enthusiast about ownerless consumption [4], [11]. While company concerns more on their capability and organizational transition require delivering combined product-service to the customer (e.g., [4], [8], [15]. Since there is only a few uptakes of PSS system, resulting in a less empirical study that evaluates the benefit of PSS. Lack of empirical evidence arguably leads to the company hesitation to adopt this system [4], [8]. Table 2 presents the summary of PSS barriers from literature.

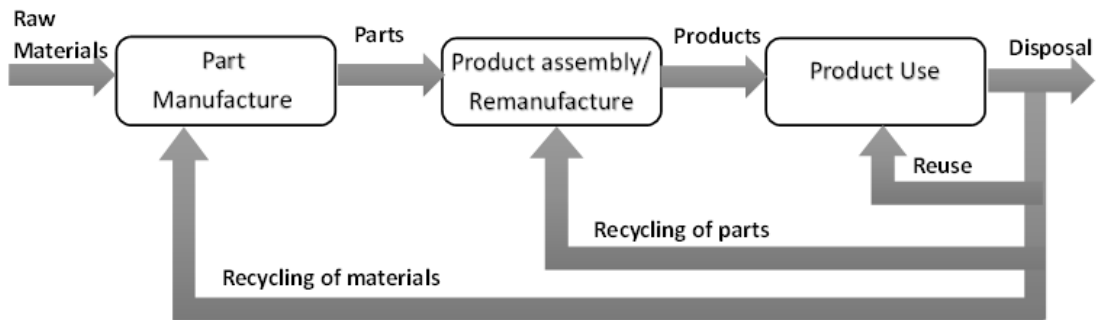


Fig .1 The physical product life-cycle [10]

Table 1. Summary of PSS Benefits

	<i>PSS benefits</i>	<i>References</i>
<b>Consumer</b>	Improvement in total value and quality; greater diversity of choices; personalized and customized offers; released from ownership responsibilities; lower cost and problems associated with product ownership.	[4], [11], [15], [18], [25]
<b>Company</b>	Creating competitive advantage; opportunities to innovation; increase market development; increase operating efficiencies; better feedback of consumer needs.	[4], [11], [15], [18], [25]
<b>Environment</b>	Reduced waste; reduced resource used; closing material cycle.	[4], [11]

Table 2. Summary of PSS Barriers to Implementation

	<i>PSS barriers</i>	<i>References</i>
<b>Consumer related</b>	- Consumers not enthusiast about ownerless consumption; lack of engagement and awareness related to PSS	[6], [8], [11], [26]
<b>Company related</b>	- Firms concern to process capability and infrastructure which assumes to be need of high investment; lack expertise in designing and delivering the services; organizational changes	[4], [7], [8], [11], [15], [26], [27]
<b>Benefit uncertainty</b>	- Socio-environmental benefits not always significant; uncertain profitability for company; unclear benefit for consumer	[4], [8]

## 2.2.Value Co-creation: Definition and Terminology

Studies reveal that consumer's behavior currently has shifted, from previously passive and peripheral, now become connected, well-informed and active consumers [28], [29]. ICT development encourages individual to connect and to share information, feeling and idea about anything including product experience without regard to demography barriers. As the result, consumers have become knowledgeable so that they develop more sophisticated product preference. Furthermore, consumers now can

easily access information about companies, products, and its property. Consequently, companies can no longer make decision autonomously. Consumers now expect to participate more in the business system and provide an output that satisfies their personal preferences, and thereby co-create value. Additionally, shifting connection between consumers and companies that skew to the interaction-based transaction has become a challenge for emerging market, yet implies potentiality for co-creation development.

Prahalad and Ramaswamy [28] describe value co-creation process as an activity where



consumers involve in every stage of business activity (such as product design, process design, marketing, and sales). Another study suggests that not only consumers that may involve on value co-creation but also another stakeholder that have an interest in business [30]. In another word, co-creation process can be depicted as a business activity involving customers as the center of activity to create and realize the new value that satisfies both parties. Studies imply that the aim of value co-creation is to boost innovation in product design [31], [32]. Other study emphasized on “creating experience” as the aim of value co-creation process [28], [33], [34]. Agrawal and Rahman (2015) offer more objectives of co-creation process including creating value, experience, learning process, and customer satisfaction. In relevant to PSS, co-creation process in this research aims for customer satisfaction by providing various value suit to costumer’s demand.

As the costumer’s engagement on the business increases, the role of consumers and company on co-creation process is changed. When co-creation process is centered on individuals, it is more likely that company’s role shift to as facilitator [35]. However, another study suggests that both roles on co-creation process should be a parallel problem solver. Through intensive dialogue, shared learning and communication is expected to be in two-way process. As the result, the company gets more insight about the customer as the foundation to start the process. Costumer’s value and knowledge are valuable input for co-creation process.

High-level connectivity among actors characterizes Co-creation process. The network must have a function to connect business with consumers and multiple stakeholders, and also to co-create value. The network is beneficial to increase manufacturing flexibility and adaptability to respond to various costumers’ value demand. Normally, companies initiate alliance, networking and collaboration among business. Nevertheless, under co-creation framework, as well as connect to other costumers, customers may start to initiate network with particular suppliers or resource owner to satisfy their needs. The higher the level of connectivity, the better co-creation process capability. However, the high-degree network can be hard to manage. Trust issue becomes another challenge for companies involved.

Well-informed costumers trigger value co-creation indicates that knowledge is important factors for co-creation process. A customer with knowledge tends to demand more based on their preference. In response, the company should be ready to accommodate and facilitate the consumer need by equipping themselves with a library of knowledge associated with the process, problem together with problem-solving, and related aspect. On the other hand, costumer’s knowledge level concludes their engagement level on co-creation process. Hence, business knowledge is necessary to realize and facilitate uninformed costumer’s value demand. Those three factors are considered to be significantly influencing co-creation process.

### **3. PSS Transition Assessment Tool Deveopment**

This section outline PSS transition assessment, adopting PSS typology concept. PSS transition assessment is developed in attempt to measure the current state of manufacturing practice in PSS context so that further improvement can be measured to guide the transition for advance PSS. Firstly, a brief description of PSS categories from the amount of research is presented. The next step is conducting qualitative analysis to get general insight to determine the key character that characterizes each type of PSS. Key character identification is intended to clarify the PSS type to evaluate the current state of manufacturing company practice from PSS framework perspective. While PSS typology focuses on PSS entities, this study incorporates PSS objectives into the assessment tool, to depict the system performance. Examples of PSS practice is chosen from the previous research in this field to demonstrate the evaluation by the instrument.

#### **3.1. Identification of Common Character on PSS Typology**

PSS typology is used to explain the essence of product-service concept as well as to describe various PSS implementation within existing industry [12], [14]. This study chooses three PSS typology that has been developed for the last decade. The most widely used PSS typology was developed by Tukker [13]. He divided PSS business models into three categories regarding creating, delivering and capturing value. The

categories namely Product-Oriented model, Use-Oriented model, and Result-Oriented model. Nevertheless, Van Ostaeyen et al. [14] argued that the categorization need to be refined, since it failed to capture the complexity of PSS found in reality. Afterward, Ostaeyen et al. proposed new typology in which developed using Functional Hierarchy Modelling (FHM) approach with five types of PSS as the outcome. PSS business model is categorized based on the mechanism to create revenue. The last typology that relevant to this research is from Adrodegaria et al. [12]. The study was developed based on Canvas model and carried out an exploratory survey among European companies to understand the model business character associated with PSS context. The description of each PSS typology is presented in Table 3.

Qualitative analysis toward PSS typology has been conducted. Each of PSS typology is compared to another, and similar character of each type has been identified. Enabling the comparison, this study develops a matrix to describe the division of PSS typology, as well as to describe the transition of the business model. This study found, even though the basic of categorization are distinct for each PSS typology, the final description of PSS types share similar characters, including consumption pattern, which represented by property right, and the type of value proposition, as shown in Figure 2.

Regarding consumption pattern, overall typology agrees to focus on the ownership of the tangible assets. PSS promotes ownerless consumption and assumes that without product ownership, resource consumption can be reduced, results lower environmental impact. Conversely, traditional consumption that focuses on product selling, albeit with better technology efficient, may lead to the rebound effect. The fact manifests that the shifting ownership associated with the environmental performance of the business model.

The type of value transfer-based activity of each type is also found to be similar. Despite the distinction of the categorization based, PSS typologies point out similar conception of value capture and transfer mechanism between provider and customer. In which this conception determines the level of PSS servitization. For traditional consumption value proposition lies in the product. Hence, the revenue mechanism strongly depends on the product. Service is

offered and sold separately from the product itself. Some offer service to support and increase sales.

Furthermore, another business model exists, in which not only offering after sales service but also provide service before product selling. Combining more service into product sales may lessen the value dependency toward the product while maintaining revenue yet increasing the sophisticated level of business process and activity. Hence, the type of the offers indicates the requirement of system capability to create intangible value that satisfies the customer.

As for ownerless consumption, Figure 2 (reveals that the lower the dependency of the value proposition to a particular product, the more value option can be created for the customer. When the value proposition is firmly associated with a particular product, it is more likely to limit the possibility of value creation for the consumer, and therefore, impact to their satisfaction. For service with high dependency to a particular product, consumer allows accessing the product function as designated by the provider. At this sense, the consumer is charged based on a period of access to a product/service, without concern to how it is used. The mid level of servitization focuses on providing service through the usage of the available product. It is similar to the product-oriented business model, without transfer ownership to the customer. The company provides facilities for the customer to create their value through service. In this case, pricing should consider risk during customer usage. The highest level of servitization is to deliver particular result or performance disregarding the product itself. The company should be able to produce expected intangible result for consumer through the combination of product and service within the system. As well as traditional consumption, the level of value-product dependency effect to the requirement of system capability to deliver various values for the customer.

### 3.2. PSS Matrix Transition Development

As reveals on Figure 2, the type of product-service lies within a spectrum of combination product and service. The type of PSS is determined by the given character of the business model. For having knowledge of company's position within the spectrum will benefit in determining the changes that required

to evolve into more advanced PSS implementation.

Based on generalization of PSS typology, PSS matrix transition is established to assess the state of the company within the PSS spectrum based on identified indicator. The indicator will associate to expected output of PSS as discuss below. The result can be used to determine the direction of strategy development to evolve into advanced PSS.

### ***3.2.1. Environmental Performance and Consumption Pattern***

As previously mentioned, that PSS has two major goals to be achieved, involving environmental and customer satisfaction. Figure 2 implies the correlation between the business models with the expected outcome of PSS. Accordingly, several indicators are identified to predict PSS performance. Discussion in PSS typology focuses on product and service proportion within the product-service continuum, point out that the higher the servitization level, the better the environmental performance. The servitization level that predicts PSS environmental performance is shown in Table 4.

However, looking up to customer value, which embraces various level and dynamically changing, the correlation may not be linear to the product and service combination. Therefore, despite the servitization level, it is more likely that the system capability to accommodate various possible customer value that influence customer satisfaction level.

The ability of PSS to respond to the various type of customer value demand is very crucial to achieve PSS goals. Capability to create and cope with dynamic value demand embraces advanced infrastructure and complex network of supplier and competencies [36], [37]. In an effort increasing system capability, co-creation approach is believed to be beneficial to elevate PSS capability for continuous innovation to create and deliver value, as discuss in the next section.

### ***3.2.2. Incorporating Co-creation to increase system capability***

Mont [4] believes that the lack of PSS adoption

in industry occurs because of consumers at the moment are not ready to accept the concept of PSS. Customers are considered to be less enthusiast about value-in-use rather than value-in-exchange. The idea of ownerless consumption proposed by PSS appears to be difficult to imagine by consumers.

This circumstance requires cultural shifting [11] where consumer value every aspect related to the product, more than the product physics. Fortunately, shifting of consumer behavior and customer-defined value has been observed [28]. The same study also argued that consumers are becoming well informed, connected and empowered, creating a smart consumer who initiates to develop their definition of value toward product or service.

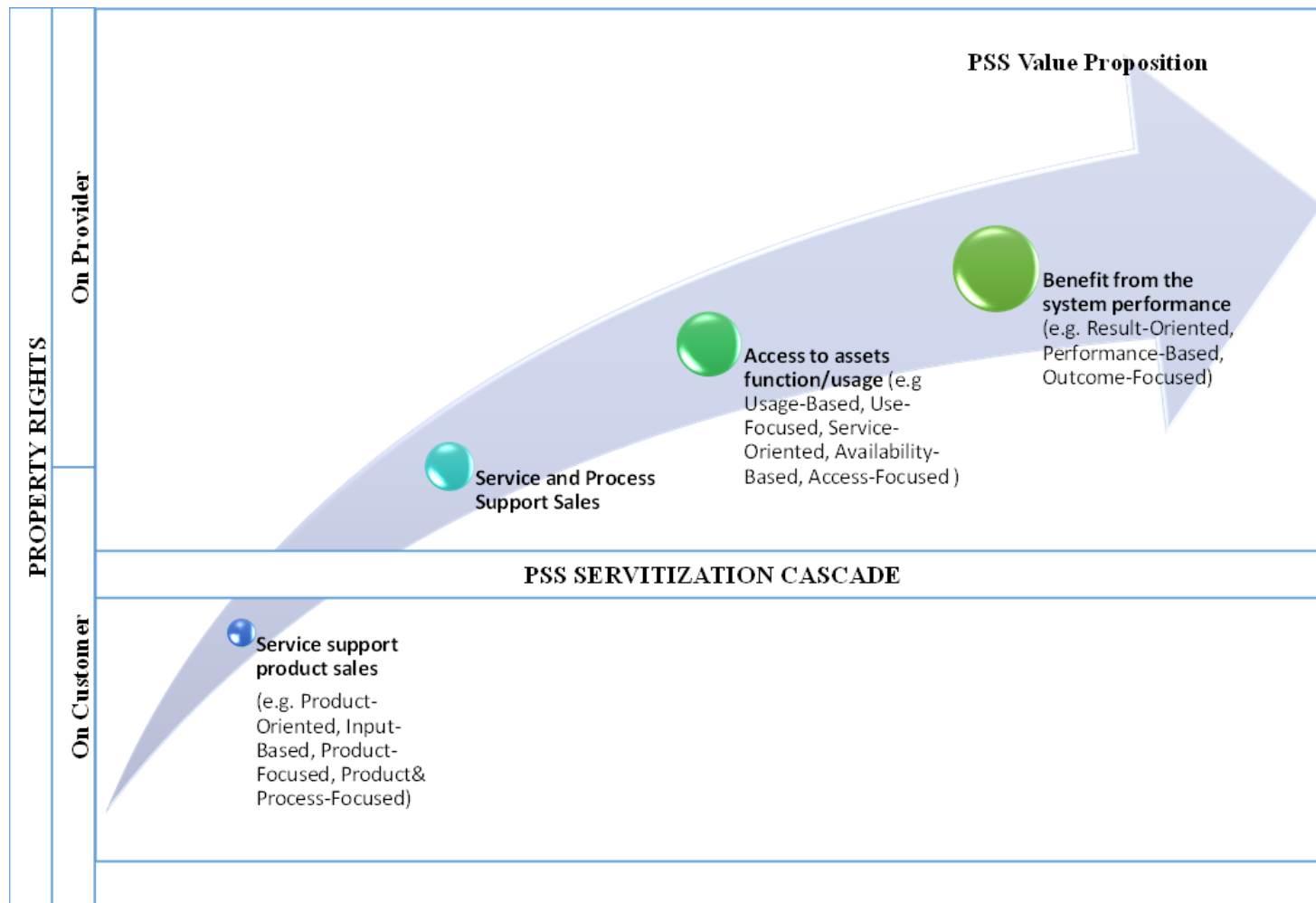
Consumer value is shifting from product centric to more personalized value. These shifting may not likely directly counteract the first barrier of PSS uptake by industry. However, it may lead to further consumer value shifting which is expected in PSS. Personal value satisfaction of each customer may direct them into ownerless consumption. Furthermore, the occurrence of consumer behavior become the motivation for value co-creation process development to increase consumer satisfaction which arguably incrementally decrease. Therefore, this study argues that adopting value co-creation into PSS framework is potential to face the barriers of implementation, particularly from the consumer perspective.

The idea of co-creation process also occurs in an attempt to create a competitive advantage for business. Despite the various strategic to increase customer satisfaction in an efficient manner, existing company are indicated to be less able to differentiate themselves [28]. Future business is expected to deliver more personalized product/service following consumer preference, and therefore, co-creation process becomes necessary. Additionally, the concept of co-creation process is more than selling goods. The idea of this process is to create experiences by delivering various product/service to satisfy personal consumer needs and value. This study found that value co-creation and PSS has a slightly different objective, yet the similarity is apparent. Both concepts are engaged to dematerialisation.



Table 3. PSS Typology in Literature

Categorization Based	PSS Category	Description
<b>Type 1:</b> Based on the building block of the business model framework [12]	Product-focused PSS type (GROUP A – Ownership oriented)	- Provider sells the product separately from the customer service needs during the usage phase.
	Product and processes focused PSS type (GROUP A – Ownership oriented)	- Similar to product-focused PSS - The difference is the service is provided both in the pre- and after-sale phases.
	Access-focused PSS type (GROUP B – Service oriented)	- Customer pays a <b>fixed regular price</b> to have access to the product or service - Service comprises preventive maintenance, product upgrade, retrofit, and revamping - Relational interaction that covers extended period of time
	Use-focused PSS type (GROUP B – Service oriented)	- Customer pays a <b>variable price</b> that depends on the usage of the product - The company is responsible for the whole product cost during lifecycle - Pricing mechanism should consider risk aspect.
	Outcome-focused business PSS type (GROUP B – Service oriented)	- Customer pays the price based on the outcome according to a contract agreement in terms of product/service performance or the result of its usage.
<b>Type 2:</b> Based on creating, delivering and capturing value [13]	Product-oriented (PO) model	- Provider delivers a service in addition to selling a product - Product remains with customer
	Use-oriented (UO) model	- Provider does not sell a physical product - Product available under rental or leasing agreements - Ownership remains with the provider
	Result-oriented (RO) model	- Provider delivers result or outcome - No specific product is involved - Provider is paid based on the result they deliver to customer
<b>Type 3:</b> Based on Functional Hierarchy Modelling (FHM), focus on the level of integration and the performance orientation of the dominant revenue mechanism [38]	An input-based (IB) revenue mechanism	- Product property is transferred to the customer - Revenue is generated together with the ownership transfer
	An availability-based (AB) revenue mechanism	- Revenue transfer occurs <b>based on the period</b> during which the product or service is available for the consumers
	A usage-based (UB) revenue mechanism	- Revenue is generated only during the actual usage of product or service - Usage can be expressed in time units or other units that associate to the usage dimensions
	A performance-based (PB) revenue mechanism	- Revenue is generated from the functional performance of product or service
	A solution-oriented performance based (PB-SO) revenue mechanism	- Revenue is generated based on particular solution-specific functional performance indicator.
	An effect-oriented performance based (PB-EO) revenue mechanism	- Revenue is generated according to the aim of environment –specific functional performance indicator.
	A demand fulfilment-oriented performance based (PB-DO) revenue mechanism	- Revenue is generated according to a subjective functional performance indicator that expresses how well a customer demand is fulfilled.



**Fig. 2** PSS major categorization

While the lack of PSS uptake by company concern to economic benefits uncertainty, value co-creation aims to offer experience and more value rather than just a goods to increase profitability. Accordingly, this study argues that value co-creation strategy can be adopted into PSS, henceforth the wavering about profitability under PSS framework can be disregarded. Regarding industry's readiness, system capability to deliver product-service for consumer deters business to adopt and implement PSS. Apparently, effective PSS become more complex for existing manufacturing organization in which currently only deliver functionality through the provision of the product alone. PSS requires significant modification in industrial system and organizational structure to increase system capability to deliver combined product-service [11]. Another study argues that company resistance adopting PSS due to rejection to extend involvement with a product beyond point-of-sale since this lead to intra-organizational and inter-organizational changes, as well as fear of innovation [4]. Due to the absence of implementation, researchers found it was hard to evaluate eco-benefit from PSS. At the same time, they assume that the lack of proof of PSS eco-benefit has been the obstacle to industry for PSS implementation [4], [6], [11], [18].

Hence, from above discussion the author to summarize the finding from literature review regarding barrier of PSS implementation as shown in figure 3.

The verdicts from previous discussion exhibits as below.

**Verdict 1:** Regarding barrier related consumer readiness to accept PSS concept, it has been argued that consumer behavior shifting has been observed and trigger value co-creation process, while at the same time potentially lead to PSS implementation.

**Verdict 2:** *The business concerns about the competitiveness of PSS to create profit while value co-creation process is intended as a strategy to increase business profit.*

**Verdict 3:** *Business resistance adopting PSS resulting difficulties to evaluate eco-benefit of PSS implementation. Nevertheless, researcher argues that this lack of evidence lead to company resistance to PSS implementation.*

According to the verdicts, this study found that critical factors of PSS adoption by industry

is evolving around industrial capability to deliver product-service offers for consumer satisfaction while reducing material consumption. Various studies have been done discussing PSS framework in operational level. This paper divided previous studies into three categories consist of P-S design, tools and methods and operational structure.

Studies in P-S design focus to resolve the sophisticated process design under PSS framework. [39] propose a design guideline for PSS, which based on Software Engineering Methods and Theory (SEMAT). This tool is intended for the designer, to organize reliably what they should accomplish during PSS design process. Another study proposed System-In-Use (SIU) Method, in which using a matrix as tools, to generate a conceptual design for PSS

quantitatively and qualitatively [40]. Studies related P-S design mostly involve single stakeholder [39], [41], only a few study include multi-stakeholder in the design stage (e.g. [42]).

Research in tools development proposed decision support system (DSS) to organize efficiently, varied range of task, concept, and resources that need to be integrated under PSS framework [22], [39]. Another study suggests a method to define a map of actors that should involve in PSS and also define requirements and structure of PSS [43].

The method is considered as very flexible tools, where narrations are necessary to define the situation clearly. Morelli [43] also suggest that more technical tools are preferable to define PSS structure, yet be probably impossible since the high of the uncertainty of real conditions.

Regarding the structure, Morelli [43] with his method presented various structure for different situations, that involving various stakeholder point out the notion of value co-creation process. This study also found correspondence in the infrastructure necessary for PSS and value co-creation process establishment. Studies imply that PSS requires knowledge, equipment and network in the various discussion of this field (e.g. [6], [7], [14], [20], [43]).

Separately from PSS discussion, studies in value co-creation also infer the requirement of knowledge, skills, resource and networks to enable high-quality interaction between stakeholders to permit co-creation process (e.g. [28], [30], [44]).

Table 5 summarize studies suggest the necessary infrastructure for PSS and Value Co-creation process. Both concept separately suggests that knowledge and resources (refer to equipment on PSS) are required for each PSS and Value co-creation establishment. The table also reveals that network is frequently mentioned in various studies implying that this dimension is strongly urged to establish to increase PSS capability as well as the dimension of the information system. On the other side, the high-quality interaction between stakeholders plays a significant role in co-creation process. This research argues that information system and networks can facilitate high-quality interaction requires by co-creation process and also to collect and integrate resources and knowledge from various source of parties involved in both concepts. Concluding from above discussion, hence authors present another verdict as follow:

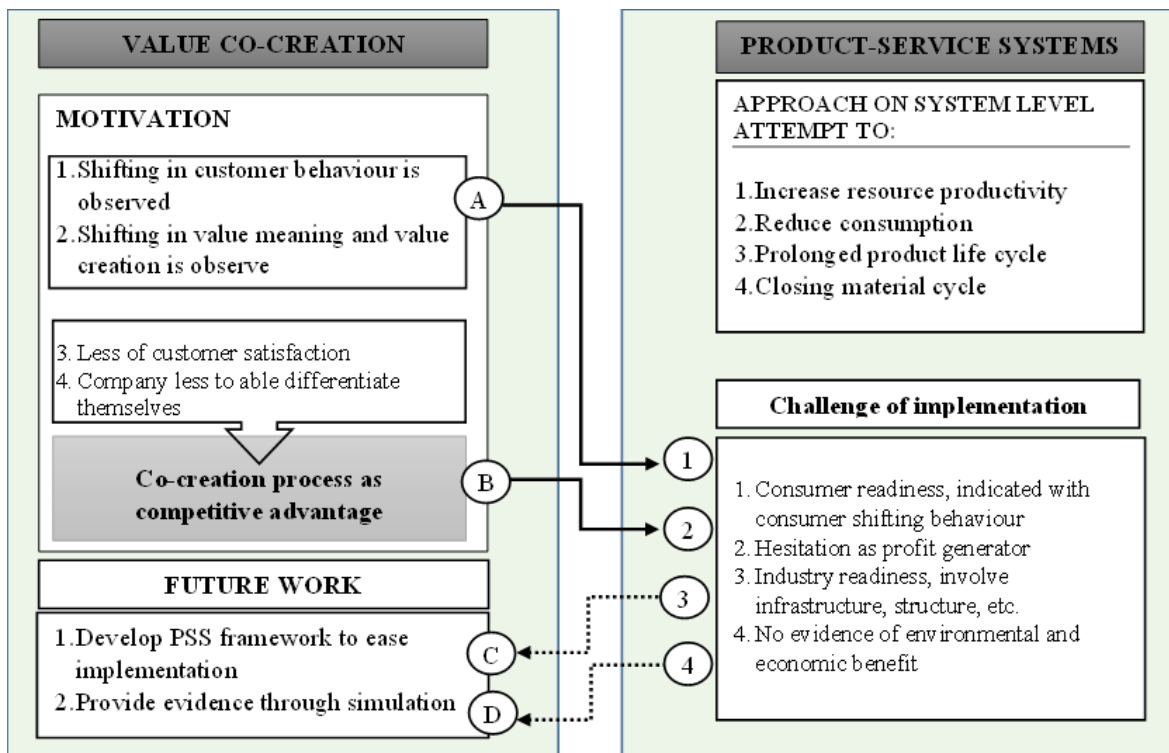
**Verdict 4:** *Separate field of studies in PSS and value co-creation imply that knowledge and skill, resources and networks are required for both PSS and value co-creation. Despite those parallels, only few research mention co-creation process on PSS discussion.*

Hence, based on above discussion, this research proposed value co-creation as a strategy for PSS framework, particularly in operational level.

Summarizing above discussion, value co-creation has the potentiality to be adopted by PSS, as both approaches are compatible and complete each other in several aspects. Value co-creation as a business strategy is triggered by existing phenomena observed in consumer preferences may disregard the firm hesitation to adopt PSS concerning consumer readiness to accept the concept as well as regarding economic benefit.

**Table 4.** The Servitization Level of PSS Environmental Performance

CHARACTERS OF SERVITIZATION LEVEL	ENVIRONMENTAL PERFORMANCE	
	LOW	HIGH
Property Rights	On customer	On company
Value transfer mechanism	Product-based, Access/Availability-based	Performance/Outcome-based, Usage-based
Value based activity	Transactional based	Relational-based



**Fig. 3** Summary of finding related to concepts compatibility



On the other hand, business capability for continuous innovation, which is necessary for PSS competitive factors has been another challenge for the implementation. In this regard, value co-creation process is mentioned to be potentially a method for more innovations. Furthermore, both concepts share similar dimension to enable the process establishment, including network, resources and knowledge. Accordingly, this research proposed co-creation strategy for PSS to increase process capability lead to higher customer satisfaction level.

### 3.2.3. *Determining Indicator for PSS Customer Satisfaction*

Process capability is a crucial thing for a company in order to deliver customer satisfaction. For PSS, the ability to innovate continuously is necessary, rather than a capacity to produce large volumes of standardized product [4], [45]. With continuous innovation capability, a company able to deliver the various design of high quality of customized goods to satisfy consumer values in an efficient manner.

Unfortunately, capability for continuous innovation while maintaining quality is not easy to do. It involves complex network to gain access and organize numerous provider of resources and knowledge. High investment is necessary to build the infrastructure, as well as inter-organizational changes for process efficiency. Nevertheless, substantial investment to increase process capability can be reduced by implementing co-creation strategy. Through value co-creation, each actor may access various information and knowledge and ensure resources sharing to boost innovation and deliver the product-service while maintaining quality efficiently.

Hence, customer satisfaction projected by system capability in PSS is indicated by the network leverage to access numerous provider of resources and knowledge, as well as the flexibility to conduct co-creation process as needed. Table 6 proposes PSS indicator to predict customer satisfaction effect to economic performance.

### 3.2.4. *PSS Transition Assessment Matrix*

Based on the indicators above, a matrix transition is built to describe the evolvement of business model toward advanced PSS as shown

in figure 4. The axis presents the outcome of the business model. Horizontal axis estimates the customer satisfaction of given business model while vertical axis predicts the environmental benefit. The matrix is divided into four quadrants, given a particular state of the company and the interaction with the customer.

The existing manufacturing industry is designed for mass production to produce goods in an efficient manner. The more they produce, the cheaper the product cost, and therefore encouraging more consumption. At the moment the technology has better efficiency, this may direct into over consumption behavior, described as the rebound effect. Hence, this matrix reveals the connection between consumption pattern with company's environmental performance. A business model with consumer ownership achieves lower in term of environmental performance as depict on the bottom row of the matrix. In contrary, ownerless consumption supported by high efficient technology, exhibited on the upper row of the matrix, creates a better environmental performance regarding material use.

The horizontal axis represents projected customer satisfaction deploying system capability indicator as parameter measurement. The indicators associate to network capacity to encourage co-creation and its leverage to access various provider of knowledge and resources. Such kind of network involves advanced infrastructure as an enabler, in which the research is currently ongoing. Network performance support with suitable infrastructure impact to system capability. The matrix indicates that low system capability to respond to customer value demand, resulting in low customer satisfaction, and vice-versa.

PSS transition matrix (as in Figure 4) exhibits PSS evolution from the current state of manufacturing company into advanced PSS practice, depicts on State 1 into State 4. State 1 reserves as the traditional manufacturing company, where the value proposition lies in the tangible product. Service is combined in the business process to support product sales. Most of the current manufacturing practice represent PSS practice in this state. The main source of their revenue is obtained from product sales, and after sales services are provided separately to support the product usage.

**Table 5.** Infrastructure for PSS and Value Co-creation Process

	PSS	Co-creation process
Dimension of Infrastructure	Knowledge (knowledge embedded in equipment) [43]	Knowledge and skills [44]
	Equipment [43]	Resources [31], [44]
	Networks [4], [7], [20], [45]	High-quality interaction between customer and company, networks [28], [31], [33]
	Information system [7], [21]	

Table 6. Indicator to Predict Customer Satisfaction Effect to Economic Performance

CHARACTER OF SYSTEM CAPABILITY	CUSTOMER SATISFACTION	
	LOW	HIGH
Network flexibility	Lessen co-creation	Enable co-creation
Network leverage	Limited	Extensive

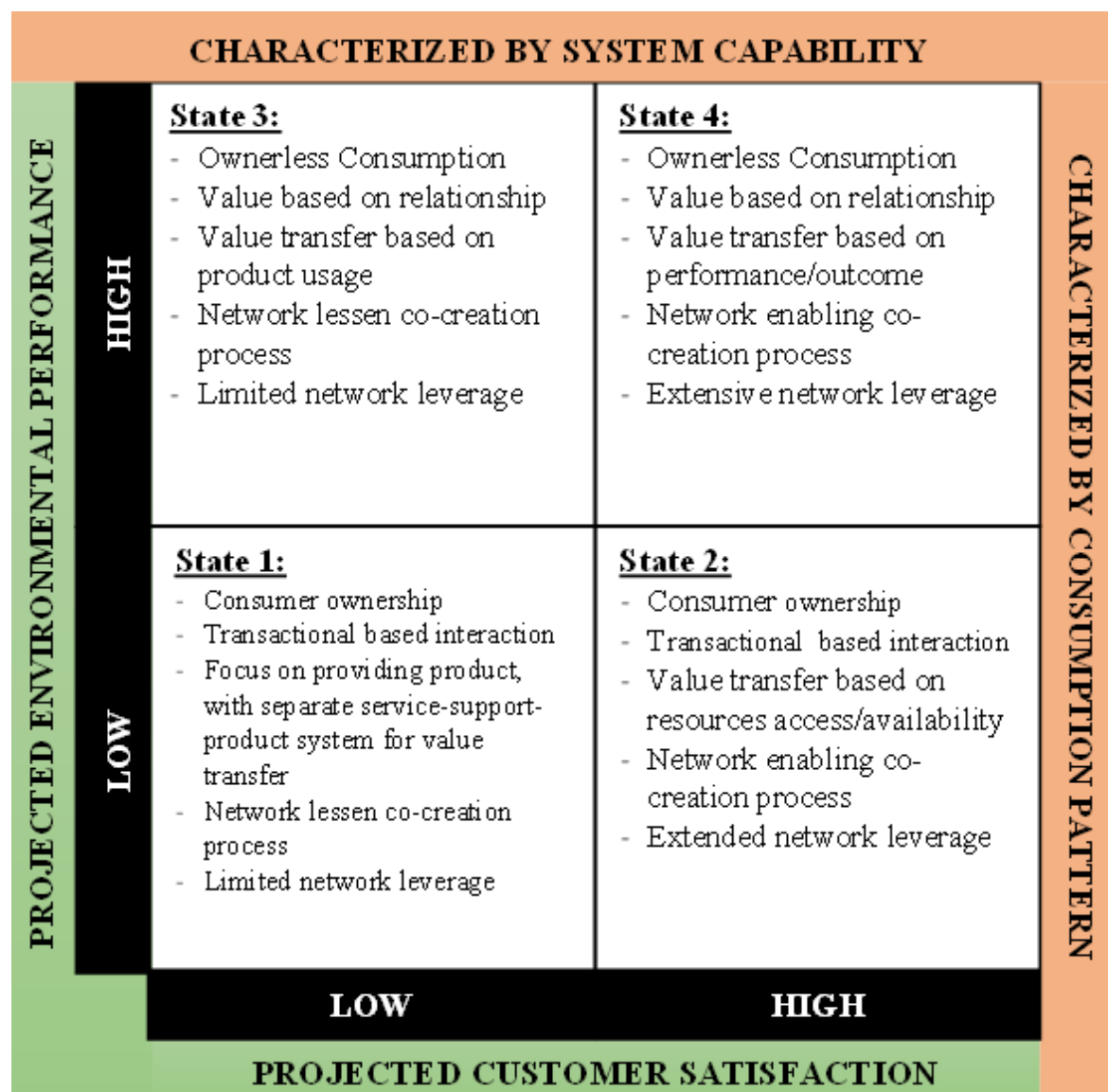


Fig. 4 PSS transition matrix

Network configuration focus to manage supply and value chain to achieve cost efficiency and production planning and control, as well as to increase the business service level associated with customer demand fulfillment. The network connects suppliers and main company to deliver designated product of the main manufacturer. The network does not allow co-creation process occurs since the delivered value has been determined.

Consumption pattern in the second state equals to the first state of PSS, but with more ration of service. Under this state company establishes infrastructure to facilitate and encourage various parties to involve in knowledge sharing and idea in expect to reduce time for product and process innovation for new value. Network configuration appears to be flexible than on the state 1. The company also builds network to integrate facilities, resources and equipment. Although the configuration is similar to conventional supply chain, yet it is more open for resource integration owned by individual. Deploying micro-factory that spread in strategic places allowing co-creation process occur creating better mass customization, but with less production capacity.

In the state 3, value transfer mechanism occurs by providing access to available product and company's tangible asset without transfer ownership. Network configuration is intended to reach a wide range of service area. The network does not involve much of external party due to focusing on providing available service based on the product function, and therefore lessen the viability of co-creation process.

State 4 depicts advanced PSS practice, the expected PSS practice, in which described as company which has capability to achieve not only higher customer satisfaction but also significantly lower the environmental impact of business activity. The company provides customer value by offering jointly product service combined without ownership transfer. Companies get revenue from service by utilizing their assets to develop a system solution for their customer. This type of value proposition requires extensive network allowing strong communication between customer and company. Through intensive communication, in-depth understanding between both consumer and company is developed, triggering co-creation process. Furthermore, extensive network

configuration is designed to span numerous source of knowledge, competency as well as resources and equipment to reduce the time for innovation in creating a solution for new value through co-creation process.

### 3.3 Evaluating Manufacturing Company Practice Applying PSS Matrix Transition

This section demonstrates the application of PSS Matrix Transition as well as to evaluate the state of PSS practice in manufacturing companies. Manufacturing companies presented on PSS literature (e.g., [26], [46], [47]) is selected and evaluated to picture the PSS implementation development in the industry. Articles from websites and case study center related to PSS practice or product to service transition business case are also examined to depict PSS practice within each quadrant. This paper has not been to investigate each example in-depth, but to describe diverse of PSS practice by manufacturing company. Improving PSS practice apparently will be discussed in further research.

Eight manufacturing companies are chosen to exercise PSS practice using PSS matrix transition. Table 7 provide a brief description of companies implementing various level of product servitization. According to description, those companies are then plotted into the matrix. Due to the insufficient description in the literature regarding infrastructure and network configuration, evaluation is mostly based on the consumption pattern, by assuming that system capability characteristic will follow. Figure 5 demonstrates the mapping result of those companies on PSS matrix transition.

Figure 5 exhibits that companies included in State 4 can be an example of an ideal PSS. The result reveals five from eight companies are in the state 4; two companies are included in the state 2, and only one company is one the state 2. No companies are identified to be included in the state 1. The example of PSS practices in literature are, in fact, is dominated by companies that implement the expected PSS practice (state 4), which are promoting ownerless consumption, and focus on providing function and access to their product and tangible assets.

Focusing the investigation toward best practice PSS companies, the customer of both companies is very specific. Both, Rolls-Royce

and Xerox selling their offers to other business, which make their business model is categorized into Business to Business (B2B). Even more, all of seven companies perform ownerless

consumption (in state 3 and state 4) target another business as their customer based.

**Table 7.** Example of PSS Practice in Manufacturing Companies

Company	Description
<b>Volkswagen</b> [25]	<p><b>Type of Product:</b> Car</p> <p><b>PSS Marketing Program:</b> ‘Mietermobil’ and ‘Wonh mobil’</p> <p><b>Value Proposition:</b> Service of mobility</p> <p><b>Description:</b></p> <ul style="list-style-type: none"> <li>- In 2000, this car manufacturing company builds partnerships with some apartment complex in German, offering service for mobility to building tenants</li> <li>- Offers a various type of vehicle maintained by Volkswagen dealer, washed by local filling stations, and used exclusively by residents of the buildings.</li> </ul>
<b>Xerox</b> [5], [14], [15], [37], [48]	<p><b>Type of Product:</b> Copier machine</p> <p><b>PSS Marketing Program:</b> -</p> <p><b>Value Proposition:</b> Volume of the photocopy</p> <p><b>Description:</b></p> <ul style="list-style-type: none"> <li>- Xerox sells a given volume of photocopying capability together with a service agreement for a period of time.</li> <li>- The company retains ownership of the equipment, while keep maintaining, repairing and replacing the component or equipment as required for a given price and volume of the photocopying.</li> </ul>
<b>Atlas Copco</b> [49]	<p><b>Type of Product:</b> Industrial tools and equipment</p> <p><b>PSS Marketing Program:</b> Contract Air</p> <p><b>Value Proposition:</b> Amount of compressed air produced by Atlas Copco’s equipment</p> <p><b>Description:</b></p> <ul style="list-style-type: none"> <li>-Atlas Copco develops, manufacture, service, and rent industrial tools and system solution (such as air compressor and assembly systems).</li> <li>-Under Contract Air Program, the company provides industrial customers with compressed air or gas at specified pressure, dew point, or purity.</li> <li>-Customer benefits from the initial cost removal of equipment and use the equipment without ownership while at the same have access for maintenance and repair service as required.</li> <li>-The fee is charged based on the consumed compressed air</li> </ul>
<b>Electrolux</b> [6], [11], [15], [48], [50]	<p><b>Type of Product:</b> Home appliances</p> <p><b>PSS Marketing Program:</b> Electrolux Euroclean</p> <p><b>Value Proposition:</b> Providing cleaning function of its cleaning machine</p> <p><b>Description:</b></p> <ul style="list-style-type: none"> <li>-Electrolux Sweden has shifted from supplying products to providing function.</li> <li>-The company retains the product ownership, and the transaction is built based on leasing and service contracts. The customer pays for fixed price to lease and service based on the contract</li> </ul>

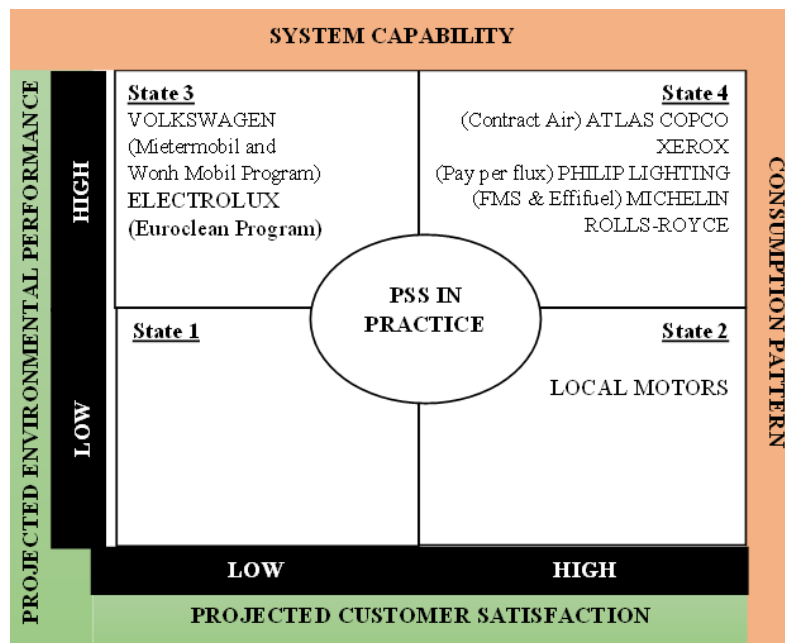


**Table 7.** Example of PSS Practice in Manufacturing Companies (Continue)

Company	Description
<b>Michelin</b> [51]	<p><b>Type of Product:</b> Tyre</p> <p><b>PSS Marketing Program:</b> Michelin Fleet Solutions (MFS) and EFFIFUEL</p> <p><b>Value Proposition:</b> MFS trade the tire's travel distance in Kilometers EFFIFUEL provide system solution, including tires management to increase vehicle productivity.</p> <p><b>Description:</b> - Michelin is a worldwide leader in tyre industry. - MFS targeted large European Transportation Companies (e.g. TNT) - For EFFIFUEL Program, Michelin partnership contractual commitment is defined based on fuel savings and the resources that are deployed across the process. The benefit generated by the solution is shared together with the partners - This business model relies on a network of service partners that extends around the globe.</p>
<b>Local Motors</b> [52]	<p><b>Type of Product:</b> Customized Car</p> <p><b>PSS Marketing Program:</b> Build Program</p> <p><b>Value Proposition:</b> Product innovation and access to resources for the market</p> <p><b>Description:</b> - A vehicle manufacturer that combines co-creation and micromanufacturing offering in a reduced time compare to other. - Provide access to the micro to build their vehicle with the help of Local Motor Engineer. The micro-factory also serves as maintenance center for a vehicle produced by Local Motors - Local Motors establishes a co-creation platform as a mean to connect and collaborate the idea between company, customer, and contributors while maintaining alliance with several major manufacturing company (e.g. Airbus)</p>
<b>Philips Lighting</b> [53], [54]	<p><b>Type of Product:</b> Lighting product, bulb</p> <p><b>PSS Marketing Program:</b> -</p> <p><b>Value Proposition:</b> Lighting solution for building</p> <p><b>Description:</b> - Philips partnering with Rau architecture agency delivers lighting solution for the building. - The clients pay only for the amount of light they use while Philip created a light plan that allows reducing the energy consumption of around 50%. - Philips providing the light plan and installment systems including the resource as needed, and customer pay for the flux of light instead of buying the light bulb</p> <p><b>Network as enabler:</b> In this case, Philips lighting acts as a supplier for RAU's agency. No particular network dedicated for PSS was established</p>

**Table 7.** Example of PSS Practice in Manufacturing Companies (Continue)

Company	Description
<b>Rolls-Royce</b> [14], [26], [47], [48]	<p><b>Type of Product:</b> Aircraft engine</p> <p><b>Marketing Program:</b> TotalCare or CorporateCare</p> <p><b>Value Proposition:</b> The performance of the aircraft engine.</p> <p><b>Description :</b> - It offers Power-by-the-Hour service package for aircraft engines, where maintenance, repair, and overhaul services are charged per hour of flight.</p> <p><b>Network as enabler:</b> This strategy strongly depends on the network to maintain a strong relationship between its maintenance infrastructures and the operational system of the product. The network includes operators, workshop, retail parts and data infrastructure located strategically across the world.</p>



**Fig. 5** Company's assessment exercise

This result aligned to Tukker & Tischner (2006) who collect PSS practice example for construction and chemical industry, in which seven out of eight companies are, actually, adopt B2B model. It seems that PSS is more attainable for B2B Company compare to B2C Company.

In the realm of PSS discussion, the differences of B2B and B2C Company comprise the buying decision driver of both customers. B2B customer aiming for efficiency and expertise in product performance, while B2C customer purchase decision is typically triggered by personal preferences. Long term contents of product/service tend to work for B2B because it requires time to prove expertise and efficiency of

the offers. On the other hand, B2C consumer prefers a product with short life cycle due to customer changing preferences. B2C model is required to be responsive to this changing preference to keep their competitive advantage.

On the other hand, rebound effect is often linked with Business to Customer companies (B2C) as end customers are the highest contributor in material consumption. Yet, study found that services that replace pure products have low market penetration [55]. Customer tend to reject such offers, if not accompanied by various possibilities of more features and value added. Designing those offers followed by process design are not viable for current

manufacturing company. Business capability for continuous innovation to respond the rapid change of customer value needs becomes necessary, yet it is hard and expensive to attain.

Under PSS framework, capability for continuous innovation, particularly for B2C is very critical, to be able to accommodate various customer preferences. At the same time to increase innovation capability to respond customer demand is very challenging since conventionally it requires high investment in human resources and infrastructure for better performance of research product development. This research assumes that value co-creation is a potential strategy for business, particularly B2C Company to increase their capability to create more value for customer satisfaction under PSS framework.

#### 4. Discussion

In the current state, PSS transition for B2B Company appears to be more reasonable, due to its consumer characteristic that prefer to retain long term value. B2B Company offers system performance, in which the satisfaction can be measured after period of time. This type of value tends to be stable, so that the need to deliver new innovation related to new value is still attainable under existing system capability. Different with B2C Company, in which they have to cope with various type of customer value that dynamically change. Implementing PSS for B2C Company is more challenging, considering alternating consumer preferences. Moreover, product cycle is considerably shorter compared to B2B companies.

The distinction indicates that different approach is necessary to guide PSS transition for each B2B and B2C Company since each of the customer is attributed with different value character. In the sense of PSS, production strategy associated with the type of value proposition is categorized into two types, i.e., mass production and mass customization [37]. Both strategies effect to the requirement of production capacity and capability, followed by suitable network configuration design.

In the context of mass production, business emphasizes on production cost efficiency considering production economic scale. In this case, it is critical to determine the optimal production capacity. The level of production capacity influence to the make/buy decision in material procurement, in which

further effect to the configuration network design associated with material and component.

On the other hand, mass customization requires sufficient technology for production process that able to respond various type of customer value demand that dynamically change in a reduced time. The technological level of manufacturing machine and equipment at some level determine the speed and ability to create and deliver customer demand. Similar to mass production, production capability is also determined the make/buy decision of material and component. Additionally, network configuration for mass customization is intended to obtain an extensive access to knowledge resources and equipment in attempt to increase production system capability. The network that connects various parties within the system is more flexible, yet complex creating an adaptive production system.

Production strategy will also determine the size of manufacturing plant. Macro-factory, a large-scale production facility is suitable for mass production strategy. Under PSS framework, components and product design should consider the easiness of feature or value extension during product usage. For mass customization, ability to create wide range of various value can be accomplished by applying micro-factory. The flexibility of production facility, combined with user creativity and knowledge, lead to numerous process innovation to create various value. Within mass customization strategy, for having new experience and doing some learning process in creating and delivering an offer can be a value itself, aside from value proposition that lies on the product.

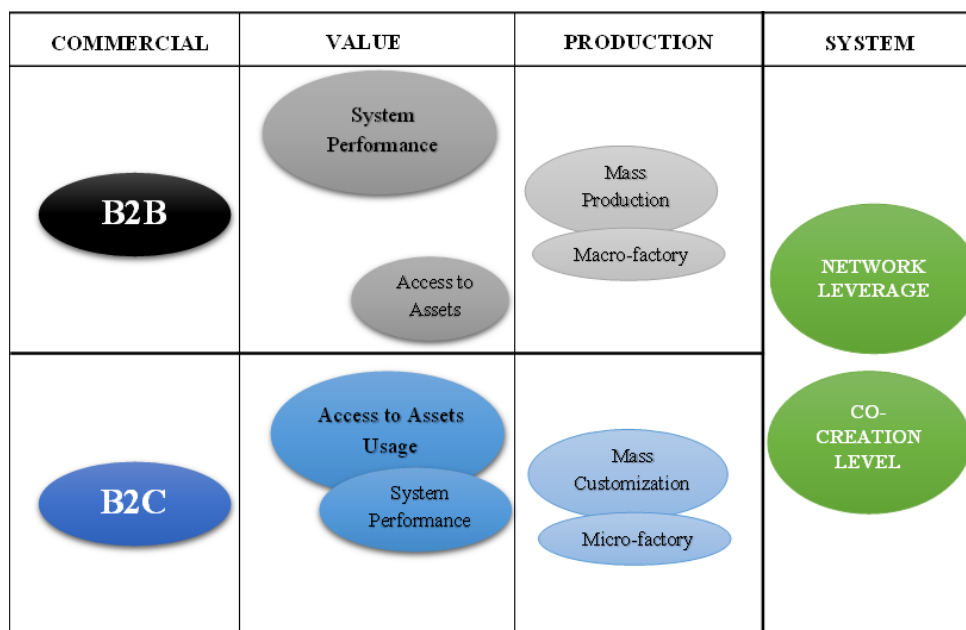
Furthermore, consumer involvement level in co-creation process is also different for each production strategy. In the realm of mass customization which aims to create new value together with customer, experience to create the offers is valuable for the client. Therefore, develop co-creation environment that facilitates the co-creation activity in every stage of the process might increase the satisfaction level. In contrast, customer involvement level in co-creation process is lesser than mass customization, requires relatively simple network configuration. In summary, determining the commercial based on the business lead to further strategic decision to support PSS transition as shown in Figure 6.

Assessment of current business in PSS practice reveals that B2B Company prefers providing system performance or one stop solution for their client. The company installs their devices from their manufacturing lines in customer's place, and revenue is transferred based on unit performance resulted from the installed system as in agreement (e.g., Rolls-Royce, Xerox, Atlas Copco). Nevertheless, there are possibilities for the company to provide access to use for their client, though it is less competitive. As presented in figure 6, mass production seems to be suitable for the value proposition, with more consideration of product-service technical design that allows customization, modification, and ease of maintenance. This strategy benefits the environment by prolonging product life cycle through upgrading, product modification and maintenance to keep the tangible asset performance and productivity.

B2CCompany tends to adopt mass customization, following the suitable offers for their customer, providing intangible value, including access, experiences, as well as customized product based on their preference. Micro-factory retailing suitable for this purpose because it is designed to be lean, agile and adaptive, thus facilitate co-creation process with various parties. Co-creation involving multi parties from multilayer is necessary to achieve higher system capability for continuous

innovation in a short time to be responsive to customer demand (e.g Local Motors).

In addition, logical flow of PSS transition can be used to guide existing manufacturer to shift into PSS practice. To determine the strategy does not have to be always initiated from commercial based identification, but it can be developed from any phase that closes to current business attributes. For example, a usual manufacturer has invested on macro-factory, yet adopting B2C business model, then shifting to B2B Company for PSS implementation seems to be feasible. Otherwise, when decides to keep going with B2C model, then invest on production facility suitable for mass customization becomes necessary. In this case, co-creation process with other parties might reduce the number of investment required for extended production facility. Bear in mind that co-creation process is different with product/process outsourcing. Co-creation process with another business may lead to an exponential number of value creation in reduced time deploying both internal asset and knowledge. Nevertheless, co-creation involvement level of various parties in delivering the offers is different for every case. Further research should be conducted to investigate mechanism of co-creation establishment for PSS and the level of actors involvement in co-creation process to support the transition in implementing PSS.



**Fig. 6** The Logical Flow of PSS Transition Strategy



## 5. Conclusions

This study reveals the potentiality of co-creation strategy to enable business in PSS transition. In the sense of implementation, the result analysis of previous research exhibits several alignments between PSS and co-creation concept, in which answer to PSS barriers appears to be immersed from co-creation attributes. Consumer shifting behavior and “smart consumer” phenomena, potential to address PSS implementation barriers associate to customer readiness. Additionally, co-creation also potential to support PSS competitiveness in sustaining profitability.

Further analysis in PSS and co-creation studies exposes consistencies between both field in regard to the significance of network and infrastructure organization for the processing establishment. Hence, this study proposes co-creation process as a strategy to support business in PSS transition.

To guide PSS transition, it is important to have adequate knowledge about the current state of PSS practice. For having understanding of existing PSS implementation benefit in identifying critical factor that needs to be improved, as well as to figure out the mechanism of incorporating co-creation process into PSS. This research developed assessment tools based on PSS typology for business practice associate to PSS namely PSS matrix transition. The tool is aimed to identify the state of PSS business practice, which is categorized into four states characterized by servitization scale and internal business capability related to network status allowing to predict the state's outcome expected by PSS.

Eight business practices, particularly in manufacturing industry, are selected from various references including scientific journal, article, and websites. This study found that one company are identified to be implementing conventional business practice with service as product support. While two companies are plotted to the third state, considered implementing PSS but with less competitive advantage.

Furthermore, five from eight business are included in the fourth states of PSS matrix, indicates that PSS implementation is viable to adopt, even with existing manufacturing system. However, three out of five business practices still focus on product sales as their main revenue. Only two companies fully adopt PSS business

model by offering system solution through their product-service system (i.e. Xerox and Rolls-Royce).

More investigation emphasizes on the fourth state of PSS matrix reveals that all of those companies are adopting B2B as their commercial based. In fact, the company on the third state also implements B2B business model. It is more likely that PSS adoption is more attainable for B2B Company rather than B2C Company due to their customer characteristic. In the sense of customer characteristic, B2C Company has more risk for rebound effect. Therefore, mechanism to guide PSS transition for B2C Company should be highlighted.

To develop a more accurate approach, this study promotes a framework to determine PSS transition strategy for B2B Company and B2C Company. The approach is differentiated based on customer characteristic, in which determines the suitable value proposition (as well as revenue mechanism) for each type of company. The value proposition governs the appropriate production strategy for PS System, and after that determine the requirement of suitable network and infrastructure to deliver the offer for the customer.

Nevertheless, the form of co-creation process itself has not been well established. This research is beginning of PSS framework development by incorporating co-creation strategy to enable PSS transition. Future research should be directed into framework development to clarify the mechanism of co-creation strategy under PSS based on company's commercial based. A simulation might be necessary to provide a clear description of the operational systems.

This paper provides a thorough review of studies on the contribution of SD modeling to the power industry. It addressed the current state of the field as well as gaps in the literature about models designed to improve project on-time delivery in the electrical industry. The power industry is confronted with numerous issues on a global scale. It's impossible to summarize all characteristics of electricity-based SD models, including their diverse objectives, time spans, and aims, depending on the region taken into account. According to the findings of the analysis, scholars have progressively advocated using SD modeling to investigate non-linear and dynamic complexity over the last two decades. It's a crucial method for simplifying complex

causal relationships at the project and industry levels.

Furthermore, it has the potential to expose the impact of contextually complex variables on project planning and control, effectiveness and performance, strategic management, and long-term sustainability. The research on electricity SD models is quite similar all over the world, highlighting the need of optimizing power plant design, output, and consumption. A survey of the literature revealed that SD modeling has made a significant contribution to the electrical sector in this research. However, additional effort is needed to fully realize the benefits of SD modeling in the electricity industry. The findings of the study provide a comprehensive knowledge of SD modeling used in Infrastructure projects, as well as insights into prospects and relevant resources for future SD modeling applications in Infrastructure research. The construction of a theoretical framework model based on the gaps revealed in this study will be the focus of future research.

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