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A framework to manage co-creation process for PSS considering the network and technology

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Abstract

This paper provides a preliminary study of framework development to manage co-creation process in order to improve customer satisfaction and environmental performance. The study clarified the importance to manage co-creation process for PSS. The discussion on PSS and Co-creation process reveals similarity regarding network and technology requirement to establish the system implies that co-creation process naturally embedded in PSS. Nevertheless, managing the co-creation process become another challenge. To manage co-creation process for PSS, this paper identified the influential factors of co-creation process considering the network and technology. The factors that included in the networks are number of actors, degree of centrality, diversity of actors and network density. The influential factors of co-creation process from technology perspective are modularity and system interoperability. The expected benefits for the company will be in terms of knowledge of co-creation management under product-service system.

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Keywords: PSS, Co-creation process, framework, network, technology

1. Introduction

This paper is a preliminary study of co-creation process management for PSS framework development. The paper aims to justify co-creation process management importance to PSS as well as to investigate the influence factors of co-creation for PSS through systematic literature review.

PSS is acknowledged to potentially address the environmental and economic problem simultaneously for manufacturing industry. However, the adoption of this approach is considered as challenging. Several factors have been identified as the challenge of PSS implementation, including customer readiness to accept PSS and company readiness [e.g.[1]].

In the sense of consumer readiness, the idea of ownerless consumption proposed by PSS seems to be difficult to imagine by end consumers. Current practice in manufacturing companies is mostly product sales oriented instead of the value that is contained in the product. Thus, customer satisfaction dependency to the tangible product is relatively high. This circumstance requires cultural shifting from valuing physical product into value by-product to introduce PSS approach. Fortunately, shifting of consumer behaviour and customer-defined value has been observed [2]. Consumer value shifted from product centric to more personalized value.

In addition, current consumers are becoming well informed, connected and empowered, creating a smart consumer who initiates to develop their definition of value toward product or service [2]. These shifting may not directly counteract the customer barrier. However, it may lead to further consumer value shifting in which expected in PSS. Personal value fulfilment may direct customer behaviour consumption from a product into value consumption.

Not only customer readiness but also company readiness in term of capability to deliver combined product-service became a challenge to adopt PSS [1], [3]. The capability represents the company's ability to combine knowledge as problem-solving related PSS. The study refers this capability for continuous innovation and is considered critical for PSS [4]. It requires

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significant modification in the system and organizational structure to increase system capability to deliver combined product-service [5].

On the other hand, value co-creation aims to boost innovation in product design [6]. One emphasizes on "creating experience" as the objective of value co-creation process [7]. Agrawal and Rahman offer more objectives of co-creation process including creating value, experience, learning the process, and customer satisfaction [8]. It can be summarized that the notion of co-creation process is aimed to increase a company's competitiveness [7]. Hence, while the absence of PSS adoption by industry concern with the ability to satisfy consumer needs without product sales, co-creation process can be a strategy to upgrade the capability and deliver more values through combined product-service.

PSS and Co-creation process are in fact shared common entities but for different purposes. PSS requires network and infrastructure [e.g.[4]], though none of the studies clarify the network and infrastructure necessary for the system. On the other hand, 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 [7]. It appears that co-creation process is naturally immersed in PSS. Hence, managing co-creation within PSS is expected to influence the PSS goals achievement.

Accordingly, this study aims to identify the influential factors of co-creation process to improve PSS performance, emphasize on the 'network' and 'infrastructure' to improve customer satisfaction and environmental performance. The 'network' and 'infrastructure' are chosen since the similarity between both PSS and Co-creation lies on those aspects. The result will be examined using simulation on the next step of the research.

2. Methodology

This study used a systematic review to identify the factors that influence co-creation process performance for PSS. Systematic review was chosen as a mean to get a comprehensive description of co-creation process both conceptually and in practice (based on case study). We adapted methodology from Tranfield et al. [9] to conduct the review, included 1) Research identification, 2) Material selection, 3) Data extraction, 4) Data synthesis.

2.1. Research identification

This stage defined objective of the research and identified the key data source. In this study, the review specifically aimed to capture the co-creation process considering network and technology. Regarding the network, this study focused on actor that involve and establish the network. Information related to actors behaviour and interaction in co-creation are observed to understand the mechanism to form the network and the characteristic of the network as the consequence of the behaviour. In the sense of the infrastructure, we focused on the technological aspects that support the network and the process. Characteristics that are required to enable co-creation process are identified.

2.2. Material selection

Authors conducted literature search mainly using Google Scholar database. The database covers research from both major and minor publisher including Elsevier, Emerald, Springer, and Wiley among others.

We used several keywords to find relevant articles, including 'Co-creation process, 'network' and 'technology'. Derivative keywords, such as 'collaboration' and 'innovation' are used considering the closeness and similarity between co-creation discussion and those topics. Bibliographies of included articles were also searched to identify additional literatures. Included articles were published between 2004 – 2017, written in English and peer reviewed. Filter from title and abstracts yielded 108 articles relevant with the research purpose. Further filter using determined categories to extract the information required, yielded 32 articles. However, this paper only present selected paper as the references.

2.3. Data extraction

Data extraction deployed a template to extract data on research questions, methods, key results, study limitation and conclusions. Further analysis were done based on given categories to answer this research questions. The categories evolve around the actors involve in the process, their behaviour and the result of the behaviour.

2.4. Data synthesis

Data were synthesized using thematic analysis, which was conducted in three steps: 1) Open coding, 2) Descriptive theme development, 3) Analytical theme generation.

3. Result

3.1. Managing Co-creation for PSS framework development

The major purpose of the study is to develop a framework that manages co-creation process to achieve customer satisfaction and improves environmental performance for manufacturing company. This research addressed such framework as Product-Service System with Co-creation or in short PSS Co-creation. For the purpose of this research, this study defined PSS Co-creation as a system that manages customer involvement in co-creating values from an offer (product or service) to satisfy their need and expectation and gives impact to better environmental performance. The definition pointed out the importance of managing co-creation process to pursuit PSS goals. This framework focused on three aspects from PSS Co-creation, in which considered the process and PSS objectives, include 1) Costumer co-creating value, 2) Customer satisfaction, and 3) Improved environmental performance. Every process and activity in the framework were directed by considering those aspects. However, this study focused on the co-creation discussion as the core process of the framework. The next section explains how the factors which influence co-creation process performance are derived from the PSS objectives as the metrics to maintain its relevancies.

3.2. Identification of PSS performance metrics

The objective of PSS included customer satisfaction and environmental performance. Customer satisfaction is measured based on the gap between customer expectation and value perceived. Customer developed expectation to available resources influenced by a series of the variable, such as family lifestyle, cultural background, demographic, and experiences. Value perceived is derived from what customer perceived after having experiences with the resources. Customer satisfaction is estimated by comparing value expect and value perceived reflecting customer satisfaction level. The level of customer satisfaction creates different impact to future demand, as a satisfied customer will most likely do repeat order, and vice versa for dissatisfied customer. In the sense of tangible product demand, increased demand lead to higher production level that may harm environment.

While it was clear that the purpose of co-creation process is to improve customer satisfaction, the framework suggested that co-creation should also improve environmental performance, since PSS aims to improve environmental performance [10], along with customer satisfaction. It indicates the difference of common co-creation practice, which is a focus on customer needs to increase product sales number. Co-creation process under PSS framework also aims to benefit the industry's environmental performance.

The environmental problem in manufacturing industry is associated with the production number to fulfill customer demand. With co-creation approach, customer is expected to free their value from product ownership and alter to another value such as service. It is expected that focusing on non-product-value will reduce the production number required to satisfy customer need while reducing environmental impact.

Based on above description, the study determines PSS performance metrics representing PSS objectives as follows:

- Customer satisfaction level, as a function of customer expectation and value perceived
- Number of purchased value, represents the unit function that contained in a tangible product (such as kilometers, power per hours), in which purchased by customer to fulfill their need. It indicates that customer satisfied with the value purchased instead the product.
- Number of purchased tangible product, indicates that customer prefers product ownership to satisfy their need. On the other hand, this metric also indicates the tangible product required to fulfil the purchased value.
- Environmental performance, estimated from purchased product. The higher number of purchased product indicates high production number together with its environmental impact.

3.3. Identification of factors that influence co-creation

Co-creation process arguably has a considerable role in improving customer value perceived [11] as well as improving customer satisfaction [12]. Customer perception of product is strongly influenced by their experience with the product. Experience mostly formed by an event that constructed from exogenous and endogenous factors. The exogenous factor is full of uncertainty and hard to manage. However, we can improve endogenous factor, such as personal experience internally through co-creation process. The current practice of co-creation process in industries takes place in various stages and forms. Most of them take place on idea generation stage, where customer provides feedback related to existing product design, packaging, and marketing. Others invite customer and community to submit design idea or compete in a challenge created by the company. Some company builds co-creation platform to facilitate brainstorming and discussion for the community that involves in co-creation process to generate a solution for the issues associated with product development. In production stage (or at least prototyping stage) a company builds micro-factory where they attempt to bring the design into reality [13].

Despite the form and stages where co-creation occurs, actors that involved in co-creation process communicate and establish relationship creating a network to provide solution [11]. Infrastructure and technology are utilized to enable the co-creation process within the network.

There are 32 articles that has been openly coded and extracted to identify the factors that influence co-creation process considering the network of actors and the technology required. The next section elaborates the founding from the literature review regarding the factors that influence co-creation emphasized on *the network* and *the technology*.

3.2.1 The Network

There have been various discussions in co-creation network [e.g. [14]]. This study focused on the network of actors which is described as a structure that connects the involved actors to transmit information and combined knowledge to solve PSS related problem. In co-creation process, the network serves a cognitive process to combine information and knowledge to provide idea and solution. Various factor that influences the network performance has been identified. Factors such as number of actor, its diversity and the structure of the network determined the network performance that affects PSS Co-creation performance.

To improve customer satisfaction, the network performance should be evaluated using measurable metrics. A project network is considered successful if it can deliver the value or function required within the expected time frame and performed as it was designed [15]. As well as for network for co-creation process, network efficiency is evaluated considering lead time process and quality of the output. Studies that proposed framework were evolving around actor's and their mechanism to provide solution through co-creation process [e.g. [16]]. Those studies provided insight of co-creation process occurs on different situation from different perspective. In extend to those research, this study structured the process correspond to the actor (including its property and behaviour) as the input of the network result in specific network characteristic and influence co-creation performance.

Systematic review with open coding analysis has identified the actors involved in the system [e.g.[11]], actor's property [e.g., [17]], and behaviour as well as the effect of their behaviour toward the network [e.g. [11]].The network consists of two components including involved actors and the information (such as value expected and knowledge) that

transmitted through the interaction among the actors. In the network, there can be various number of actors who join in co-creation process. The actors who are involved play different roles and may come from different parties. The role distinguishes the actors into initiator and contributor. The initiator is an actor who initiates the idea to co-create about particular issues related to the value expected by the customer in PSS. While contributors are actor who provide their skills and knowledge to support the process. On the other hand the level of capability and knowledge that possessed by an actor may indicate their level of contribution in co-creation process.

Co-creation process with few number of actors more likely to have simple interaction compares to the one with large number of actors. The existence of particular role affects the interaction between actors in transmitting information and knowledge. For example, the initiator will put the most effort to connect with other parties within a network to co-create a value and to solve the problem. An actor with the most resource or knowledge will more likely initiate to establish a network. Both types of actors tend to build more connections. Therefore, it seems that they tend to succeed co-creation process and become central to the network.

Being central to a network represents an actor's power within the co-creation network. Since every actor are willing to succeed the co-creation process, they encouraged to get more connected with other actors in the network. It may result in more than one center of the network in co-creation process. The number of the actors as network central seems to influence the behaviour of co-creation process.

Alongside with the actors is information conveyed by actors to each other. The more actors in the network, the greater the probability of having diverse resource and knowledge for co-creation process. The diversity of actors is necessary for co-creation process since incorporating various skills and knowledge results in idea creation [18].

On the other hand, to have all actors connected in a network will ease the dissemination of information, and is expected to increase the quality of the information. The extent to which the actors are connected within the network represents the network density. Nevertheless, high density of network may lead all actors to have common knowledge that will reduce their novelty. Hence influence to the novelty of the idea resulted from co-creation process.

This section has provided a general description of the network. It described the actor's interaction that leads to particular characteristic of network that may influence co-creation process. There are four characteristics in which mentioned and identified as the factors that affect co-creation process, included 1) Number of actors, 2) Degree of centrality, 3) Diversity of actors, 4) Network density. Next section clarifies those factors as follow. Based on the discussion above, the variable to measure the co-creation network is clarified as follows.

3.3.1.1. Number of actors

Number of actors is simply described as the size of the network that consists of various actors. In practice, co-creation process usually involves a various number of actors. Although a number of actors involved do not necessarily improve co-creation process, however, it may be crucial to take this factors into account as the influenced factors, because number of actors related to the probability to have access to various knowledge and skills. Co-creation process, similar to collaboration requires amount of access to resource of knowledge and skills to get a better result [e.g.[19]]. Nevertheless, at some point, number of actors may have a negative correlation with the co-creation, because it is hard to manage,request more agreement of rule and standards. And, thereby it reduces the ability to generate idea and problem solving in a short time [20].

Arguments thus have been made for positive and negative relationship of this variable impact to co-creation results. Further measurement should be done to validate these hypotheses and predict the number of actors involved that efficiently influence the co-creation process.

3.3.1.2. The degree of centrality

An actor usually initiates a co-creation process. This actor tends to connect with another to co-create. Numbers of connection that an actor has directly connected with other network members determine its centrality. The study considers this factor influences co-creation process because the number of connection predicts the role [21] and domination of an actor within the network. It reflects the level of contribution as well as the power in the structure. It also reflects their access to the information sources. The more connection firm established, the more access to information hence increase the wealth of knowledge to exploit and use to their advantage, in which results in shorter time in innovation delivery [21].

Nevertheless, there is a chance when a network member is all well connected, creates more than one center in the network. This situation is arguably affecting the co-creation process negatively since there is more than one actor dominate the process, where disagreement may occur and hamper the co-creation process.

3.3.1.3. The diversity of actors

This factor is considered to influence co-creation process in term of access to knowledge and skill in the network as a property of the actor. While a number of actors refer to the individual, this factors is associated with the property of the individual. This factor is in line with the discussion in co-creation process where different stakeholders involvement is necessary for value creation [e.g.[7], [8]]. This study categorizes the actors into three include customer, company, and contributor. Stakeholder diversity can be represented on contributor that involved, such as Company, Knowledge Institutes, Government, and Interest Group.

3.3.1.4. Network density

In a co-creation process, actors establish a connection from one to another develop a network. The network that well connected to each other allows the information and knowledge transfer, enable each actor to compare information from different partners, thus increases the reliability of the information [22] and manage in-depth discussion resulting collective understanding and encouraging collective problem solving [23]. On the other hand, it will result in homogenous knowledge and information, lead to the shared understanding that hinders creativity [24].

Meanwhile, a network that is not linked to each other may lead to a different flow of information. It allows the combination of different knowledge and information and thereby increase the probability for more ideas. The high-density network is easily found on current industrial network,

where companies are linked and share common information and value to compete in the same market share. Therefore, this study includes network density of the actors as one of the influenced factors of co-creation process.

3.3.2. Technology

Information transmission and communication within the network require technology as enabler. Regarding PSS, the technology should have continuous ability to respond the increased flexibility in demand (in term of amount/ production capacity) and increased product customization. This study considered two aspects of the technology, including the production machine and software. To ease the integration, the technological aspect should consider below factors.

3.3.2.1. Modularity

Modularity refers to the design system and technological component that influence the degree to which a system may be separated and recombined that enable the configuration of great variance of products [25]. One suggests that modularity positively impacts on manufacturing integration [26]. Nevertheless, modularity to some extent influences the novelty of product design.

3.3.2.2. System interoperability

System interoperability related to the ability of the technological systems to directly exchange information and service with other system and to interworking service or product from different sources [27].

This section has identified factors that influence co-creation process for PSS considering the network and technology. Finally, Figure 1 summarizes the causalities between identified factors in PSS Co-creation framework

4. Discussion

The existing co-creation theory aims for value creation to improve customer satisfaction. On the other hand, co-creation process seems naturally emerge on PSS. The proposed framework offers opportunities for company to manage co-creation process to achieve PSS goals, both to improve customer satisfaction and environmental performance. The literature review made during present study reveals that particular behaviour among actors lead to specific character of network, in which this study considered as influenced factors of co-creation process. In addition to that, technology characteristic plays considerable role to enable the interaction between actors to perform co-creation process. By managing the interaction between actors within the network and enabling technology, the company can improve co-creation performance, thus affect the PSS goal achievement.

A company can improve customer satisfaction by intervening customer perceived value. The value resulted from co-creation process is expected to improve customer product experience through new product function or improvement of existing function. Better environmental performance can be achieved when manufacturing company provides various value by improving existing product rather than producing a new product to fulfil customer need.

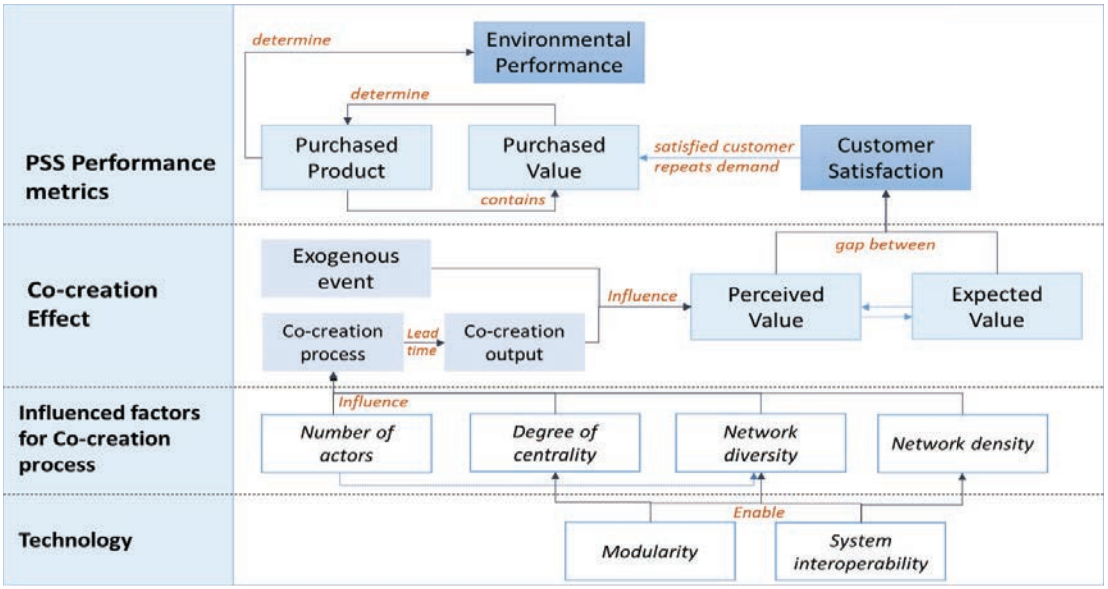

Fig. 1. PSS Co-creation framework

5. Conclusion

In this study, we have justified the importance to manage co-creation process for PSS. Co-creation process potentially addresses the issues in PSS implementation related with customer shifting behaviour and industry readiness to adopt PSS. The discussion on both subjects also reveals similarity regarding network and technology requirement to establish the system. The study concludes that co-creation process naturally embedded in PSS, though managing the co-creation process become another challenge. This framework attempts to address the challenge by identifying the influenced factors of co-creation process that may improve PSS performance, considering the network and technology. Company can have benefits not only from improved customer satisfaction but also better environmental performance.

Nevertheless, a framework development based on qualitative analysis may contain bias in measurement, since the literatures that have been reviewed evolved around conceptual design and approach instead of empirical studies.Therefore it is necessary to validate the framework employing quantitative analysis for further research.

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