

## PRODUCT-SERVICE SYSTEMS REPRESENTATION AND REPOSITORY FOR A DESIGN SUPPORT TOOL

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### Abstract

Service elements are integrated with product elements to provide diverse values in product-service systems. Product-service systems vary a lot. Some have more product elements, while others have more service elements. Some services are to support products, and others are to support customers. A representation framework of product-service systems has been devised to support design process. A total of 12 dimensions are used to represent a product-service system, including value space, service space, business model space, customer space and actor space. A repository of product-service systems based on the framework has been developed so that many product-service system cases can be stored, retrieved and reviewed when a new product-service system is to be designed. Similarities among difference product-service systems can be assessed based on the dimensions of the representation framework. A prototype repository with the proposed representation framework will be described with examples on how product-service design processes can be supported.

**Keywords:** Product-service systems (PSS), Business models and considerations, Representation, Repository

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# 1 INTRODUCTION

Service elements are integrated with product elements to provide diverse values in product-service systems (PSS) (Goedkoop *et al.* 1999), (Baine and Lightfoot 2013), and PSS vary a lot. Some have more product elements, while others have more service elements. Some services are to support products, and others are to support customers. It would be desirable to have a representation framework within which diverse PSS could be represented so that characteristics of PSS can be described in detailed enough manner. Many different perspectives on PSS should be included in such a framework.

A representation framework of PSS has been devised to support PSS design process. A total of 12 dimensions are used to represent a PSS, including value space, service space, business model space, customer space and actor space. A repository of PSS based on the framework has been developed so that many PSS cases can be stored, retrieved and reviewed when a new PSS is to be designed. Similarities among different PSS cases can be assessed based on the dimensions of the representation framework. A prototype repository with the proposed representation framework will be described with examples on how PSS design processes can be supported.

## 2 PRODUCT-SERVICE SYSTEMS REPRESENTATION

### 2.1 Dimensions to Represent Product-Service Systems

To represent diverse PSS, the following dimensions could be used. These 12 dimensions are not necessarily complete. As more viewpoints are found to be useful, those could be added. But at the moment, we found these 12 dimensions useful. These dimensions are described briefly in this section.

#### 2.1.1 Value Space

PSS should address diverse values of both service receivers and service providers. The value space should encompass value aspects presented by rapidly increasing environmental and social demand, intensified globalization, new technology, and new way of consuming and life style. Addressing recent trends, the E3 value concept of economic, ecological and experience values has been proposed in 2010 by Y. S. Kim and his research group (Cho *et al.* 2010) In addition to the E2 value concept by (Goedkoop *et al.* 1999), a new most important value category of experience values has become the most critical one. Especially because of human-centeredness and personalization trends, experience values can be divided into functional, social, emotional and epistemic values, and they are critical in both B2C and B2B.

Some experience values are extrinsic, while others are intrinsic. Function values are objective and extrinsic. Some social values like connectedness are extrinsic. But some social values like respect are intrinsic. Emotional values and epistemic values are intrinsic. Among emotional values, some values come quick and go away quick with primary contribution by the external world. These reactive emotional values are called by Scherer as aesthetic values (Scherer 2005). If one says it touches good, looks good, smells good, sounds good, and tastes good, she talks about reactive emotions. What is more important are active emotional values like love, happiness, anger, fun, and control. Summarizing this taxonomy of E3 values, the value hierarchy shown in *Figure 1* is used in enlisting specific value themes under the corresponding categories. Note that those who see new value themes would be in a position to design service activities that drive those values first.

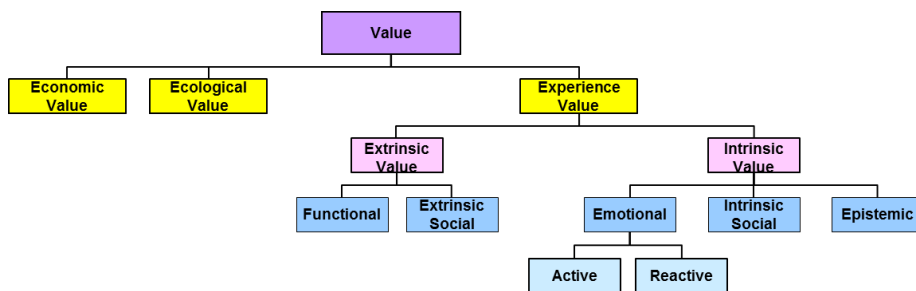


Figure 1. E3 Value Concept

### 2.1.2 Product-Service Space

The main classification of PSS into *result-oriented*, *use-oriented*, and *product-oriented* (Tukker 2004) can be used considering comparative contributions of products and service aspects and ultimate functions provided. Especially, by combining the value space and the product-service space, the relationships in the eco-system of manufacturing firm and service providing companies could be explained.

### 2.1.3 Product Space

This space addresses the classification of products that form the core starting points for PSS. Meaningful product classification can be developed for product-service businesses by distinguishing the classification of products as themselves in the conventional manner.

### 2.1.4 Service Space

Service concepts of PSS can be classified simply by the service industry categories such as installation services, rental services etc. But this kind of simple classification can not lead to critical contribution in establishing strategies for radical business innovation. It could only be used for general classification of services. More meaningful classification could be made by addressing whether the service adds as an innovative factor in supporting products' function, *service supporting product* (SSP), or in supporting enhancement of customer values, *service supporting customer* (SSC) (Baine and Lightfoot 2013).

Service space classification of 5 steps has been devised and presented in this paper. If the service supports only product functions, it is regarded as *SSPP*. If there is a little aspects for customer value support while mostly product is supported, it is *SSPc*. If the service mainly supports customer values with a little product supports, it is *SSCp*. If the service addresses customer values not directly related with the product, but critical to customers of the product, it is classified as *SSCC*. *SSPC* (or equivalently *SSCP*) represents the case where SSP and SSC are about the same. For example, simple parts replacement and maintenance services are classified as *SSPP* as in the case of typical tool PSS. Nike Plus service, for example, can be contrasted as it does not add functions of their products of sporting wear or shoes, but it changes behavior of their customers leading to more sales of their products. This kind of services is classified as *SSCC*. Evaluation of services in five grades of *SSPP*, *SSPc*, *SSPC*, *SSCp* and *SSCC* could be done by addressing dependency on products, customer competence enhancement, customization, interaction of customer services, service differentiation level, and diversity in industrial/discipline convergence as shown in Table 1.

Table 1. Classification of Service Space

	<i>SSPP</i>	<i>SSPc</i>	<i>SSPC</i>	<i>SSCp</i>	<i>SSCC</i>
Dependency on Product	Improvement of Product Function	Total Solution of Product		Low Level Dependency on Product	Few or No Dependency on Product
Expansion of Customer Capability		Low Expansion of Customer Capability with Product	Expansion of Customer Capability with Product	High Expansion of Customer Capability through Service	Change the Customer Behavior
Customization	Customization through Product Portfolio	Customization through Product-Centric Added Services	Customization of Service Interaction Touchpoints	Customization of Services for All Interaction Touchpoints	Context-Specific Customization & Personalization

Customer Interaction		Initiation of Transaction-based Interaction	Establishment of Transaction-based Interaction	Cultivation of Relation-based Interaction	Establishment of Relation-based Interaction
Degree of Differentiated Service	Differentiated Service through Product Quality Improvement	Differentiated Service Integrated with Product		Offering of Customer-oriented Service	Differentiated Service through Customer-oriented Service
Convergence with Various Industries	Convergence for Improvement of Products	Convergence for Product-Oriented Services	Establishment of Strategic Alliance with Service Providers	Introduction of Convergence for Customer-oriented Services	Establishment of Convergence for Customer-oriented Services

### 2.1.5 Touchpoint Space

Service is provided through the interaction between provider and receiver. The form of the interaction and mediation could define the characteristics of PSS. For example, a bank operation could be through face-to-face interaction, through ATM machine or the Internet. In this case, the service is identical but touchpoints of the service encounter have different characteristics. In this way, the characteristics of PSS is determined by the classification of customer touchpoints.

### 2.1.6 Customer Space

The representative distinction of services is that services could not be done without the role of service receivers. Sub-spaces of the customer space are consisted of the customer types, forms and levels of the customer interaction and level of the co-creation with customers.

### 2.1.7 Business Model Space

In the case of business model canvas (Osterwalder and Pigneur 2010), the business models are described with the aspects of customer segment, customer relationship, channel, key partners, key activities, key resources, cost structure, revenue stream, and value proposition. We then identified diverse strategies for each aspect based on many business cases (Lee *et al.* 2011). Using these aspects and strategies, the biz model space is defined.

### 2.1.8 Actor Space

At the phases of planning, developing and operating of PSS respectively, which company or organization play the role of *active actor* would contribute critically in classifying PSS. The actors in the process of servitization planning could include various parties such as planning department of the manufacturing firm, business consulting firm, service design consulting firm and service provision expert. The cultural characteristics and organizational structure of the actors are important. Also the characteristics of competitors, partners and co-operators are to be handled in the actor space.

### 2.1.9 Society Space

Not only the customer group and the provider company, but also market, media, and policies that have effects on launching and sustaining of the product-service integrated business comprise the society space.

### 2.1.10 Context Space

The diverse contexts, such as market situation and trend of technology, of the manufacturing company which develops new PSS business would form the context space.

### **2.1.11 Time Space**

The time space would be consisted of planning duration, development duration, and the time characteristics of entering into the market, growing and stabilizing.

### **2.1.12 Environment Space**

The environment space would include geographic characteristics of the market and the characteristics of service provision circumstances.

## **3 PRODUCT-SERVICE SYSTEMS REPOSITORY**

### **3.1 Repository**

PSS cases have been represented in the repository so that these can be referred to when a new PSS is to be designed. The current implementation includes about 60 PSS cases including those developed at the PROTEUS consortium led by the TU Denmark (McAloone *et al.* 2011) and those developed at the University of Antwerp (Dewit & De Roeck 2014) as well as those developed at the consortium of Manufacturing Servitization Support Framework (Kim *et al.* 2015).

### **3.2 Similarity Assessment**

PSS cases can be compared using the twelve dimensions or parts of them to retrieve similar cases and to get some insights for new service concepts from similar cases. Currently, similarity assessment methods for three spaces of value, service and business model have been developed in the repository system. The detailed explanation of the similarity assessment methods is not within the scope of this paper, but it can be found in (Kim *et al.* 2014).

The similarities of 20 PSS cases in the biz model space is for example shown in *Figure 2*, where the comparison of two specific cases is shown in detail in biz model space. Through this chart, the researchers can figure out comparison of the scores at a glance. The similarity results are shown in different colors according to its score. Blue color means that the score is above 0.9; in case of green colour, the score is above 0.8 and red color represents low score which is below 0.6. For example, *Happy Toaster PSS* and *Toy Sanitizer PSS* have 75% similarity on the biz model space. Happy toaster PSS is a function of toaster that makes a short sentence on a toast as a user wants. Toaster users can send simple messages to their acquaintances through this service. Toy sanitizer PSS is a service that a service person visits customers who want to clean their child's toys. The service person might counsel with customers who on parenting in general. The similarity score of two PSS cases is 0.75 reflects that 4 strategies of the biz model, *added service* in customer relationship aspect, *internet (mobile)* in channels aspect, *niche targeting* in customer segment aspect and *pay per use* in revenue streams aspect as boxed, are common in 4 respective aspects. Note that strategies are shown in red, and other remarks are in blue in *Figure 2*.

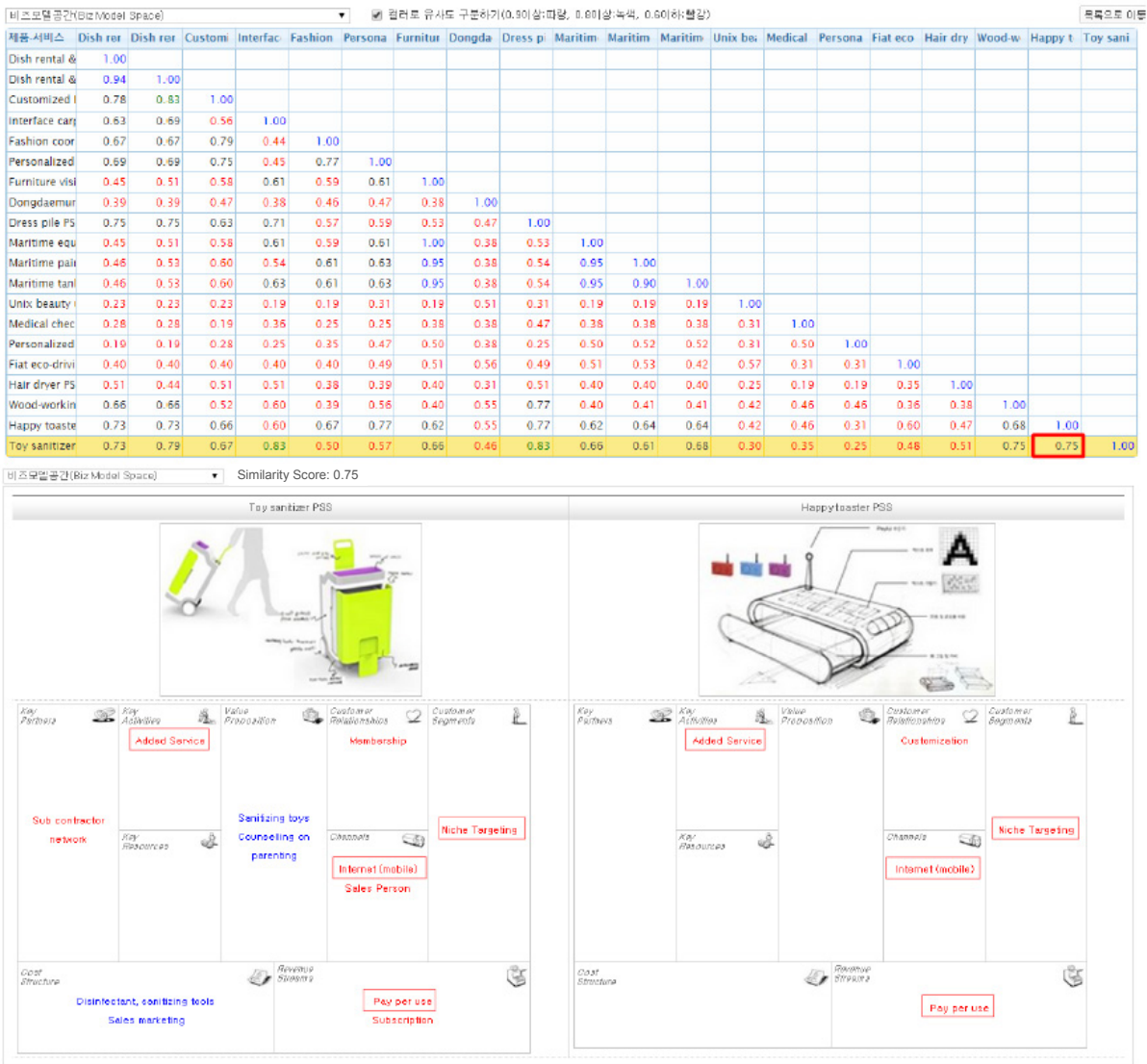


Figure 2. Similarity Assessment of Biz Model Space

### 3. 3 Example of Wood-working Tool Rental PSS and Personalized DIY Furniture PSS

PSS repository could be used to compare a number of PSS based on their similarities. Two or more PSS cases are chosen and then, the similarities of them in each space is calculated. Using this score, PSS similarities are estimated. In this section an example of comparing *Wood-working Tool Rental PSS* and *Personalized DIY Furniture PSS* is given to help understanding the role of the repository. This example explains how we can get insights from other cases by using the repository. These two PSS cases have quite high similarity, 75%, on the biz model space as shown in *Figure 3*. This means they pursue similar business strategies. On *Wood-working Tool Rental PSS*'s strategy, key partner is *subcontractor network*, customer relationship is *customer participation*, channel is *internet (mobile)*, customer segment is *niche targeting*, and revenue stream is *pay per use*. On *Personalized DIY Furniture PSS*'s strategy, key partner is *sub contractor network*, key activity is *added service*, customer relationship strategies are *customer participation*, *life-cycle care* and *customization*, channel is *internet (mobile)*, customer segment is *niche targeting* and revenue stream is *subscription*. They both have *subcontractor network*, *customer participation*, *internet (mobile)*, and *niche targeting* in respective aspect. On the other hand, *customization strategy* of customer relationship aspect is used only in *Personalized DIY Furniture PSS* case. This strategy could be added to *Wood-working Tool Rental PSS* case to enhance its service.



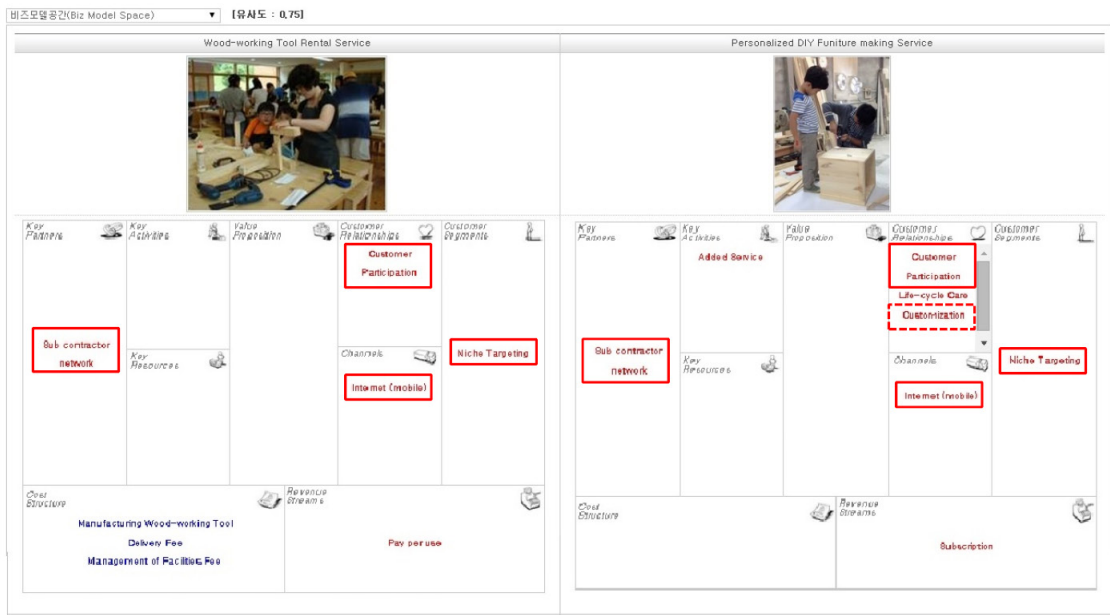


Figure 3. Biz Model Comparison of Wood-working Tool Rental and Personalized DIY Furniture

In Figure 4, the value spaces of the two are shown. First, Wood-working Tool Rental PSS pursue *cost reduction* as economical value, *connectedness* as extrinsic social value, *fun* and *achievement* as active emotional value, *diversity* and *information* as epistemic value. Secondly, Personalized DIY Furniture PSS pursue *customization* as functional value, *connectedness* as extrinsic social value, *fun* and *achievement* as active emotional value, *comfortable* as reactive emotional value, *knowledge* as epistemic value. The difference is *customization* as functional value on Personalized DIY Furniture PSS, and this value is driven by ‘DIY Education’ service as shown in the service space of Figure 5. Wood-working Tool Rental PSS has ‘Tool Rental’ and ‘Tool Delivery’ service on SSPc, and run ‘Community’ and get some ‘Expert’s Counsel’ service on SSCC part. On Personalized DIY Furniture PSS, ‘Furniture Choice’ is on SSPP, ‘Furniture Delivery’ is on SSPc, ‘Doing DIY’ is on SSPc, ‘DIY Education’ is on SSCp, ‘Community’ and ‘Expert’s Counsel’ are on SSCC. As Figure 5 describes, ‘DIY Education’, located in SSCp of Personalized DIY PSS, represent customization strategy on its business model. To strengthen ‘Wood-working Tool Rental PSS’s business model and its own service, ‘DIY Education’ could be added to its service space. Then, Wood-working Tool Rental PSS could strengthen their service offerings. In this way a PSS case can be improved by learning from a similar PSS case of the repository.

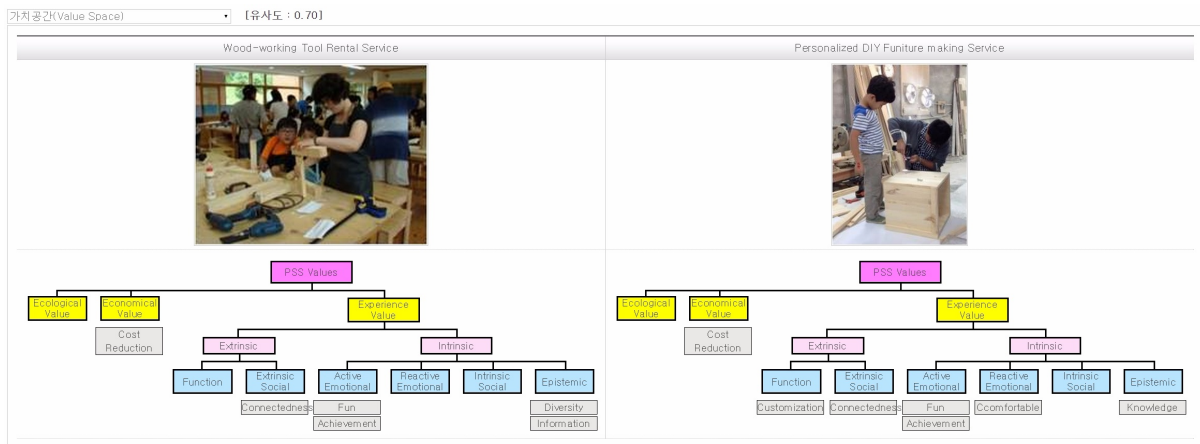


Figure 4. Value space comparison of Wood-working Tool Rental and Personalized DIY Furniture

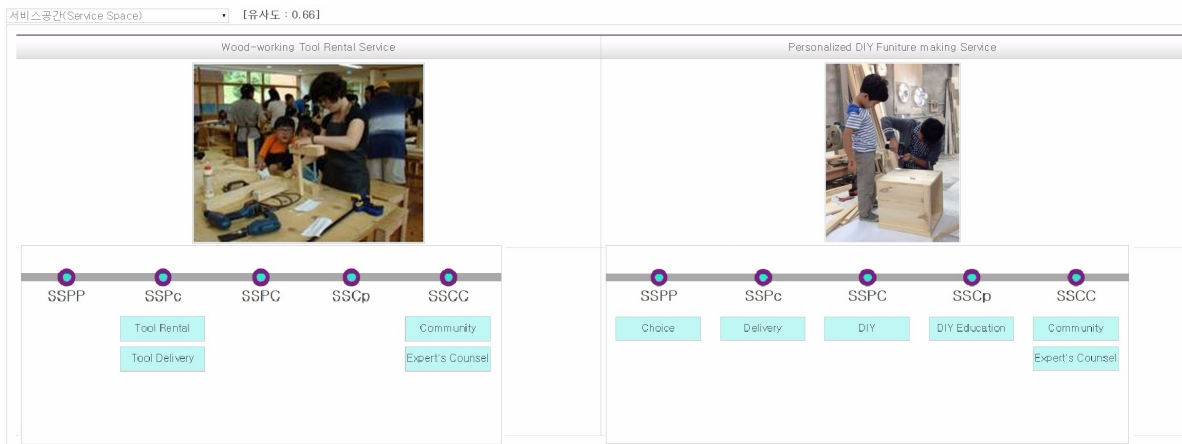


Figure 5. Service space comparison of Wood-working Tool Rental and Personalized DIY Furniture

### 3. 4 Example of Bicycle Self-repairing PSS and Scooter Rental PSS

As another example, two cases of *Scooter Rental PSS* and *Bicycle Self-repairing PSS* are considered. The value spaces of Bicycle Self-repairing PSS and Scooter Rental PSS are shown in Figure 6. The score of similarity is 0.82 which is high similarity. Common values are *cost-reduction*, *connectedness*, *boast* and *knowledge*. Both PSS cases have multiple service offerings on SSCC and no SSPP as can be seen in Figure 7. Thus their overall service space characteristics are relatively similar, while the detailed offerings are different. The biz models of two PSS are shown in Figure 8. The similarity of two PSS is 0.5 and this is not high similarity. There are only one common strategy in their biz models.

However, the characteristics of two PSS are quite different. Bicycle self-repairing PSS is a service that bicycle manufacturer supports customers to fix their bicycle by himself. Moreover its membership service makes continuous revenue. That is, product manufacturer is the main business organization in this PSS. On the other hand, Scooter Rental PSS has been designed so that a rental service firm buys scooters from different manufacturers, and the firm lends to customers who want to travel using scooters. The firm provides customized travel routes and contracts with local restaurants and accommodations. The commission is main income. In the result, the main actor of this service is the rental service firm. That is, while two PSS has high similarity in value space and service space. This means that the two PSS seek similar values and pursue relatively similar emphasis on service supporting customers as shown in the service space. However, the direction of PSS business is decided by active actors of running PSS. Thus consideration of the actor space is essential to compare the PSS cases. The actor space could be composed of planning team of manufacturer, business consulting firm, service design firm and service experts. What they do at the level of planning, developing and operating are crucial parts in PSS business design. This space could also reflect the characteristics of the organizations, competitors, partners and co-operators. Including the actor space when analysing PSS similarity would make contributions. Examining PSS similarities from diverse point of views could enhance understanding about PSS cases and help more effective design in product-service integrated business concepts.



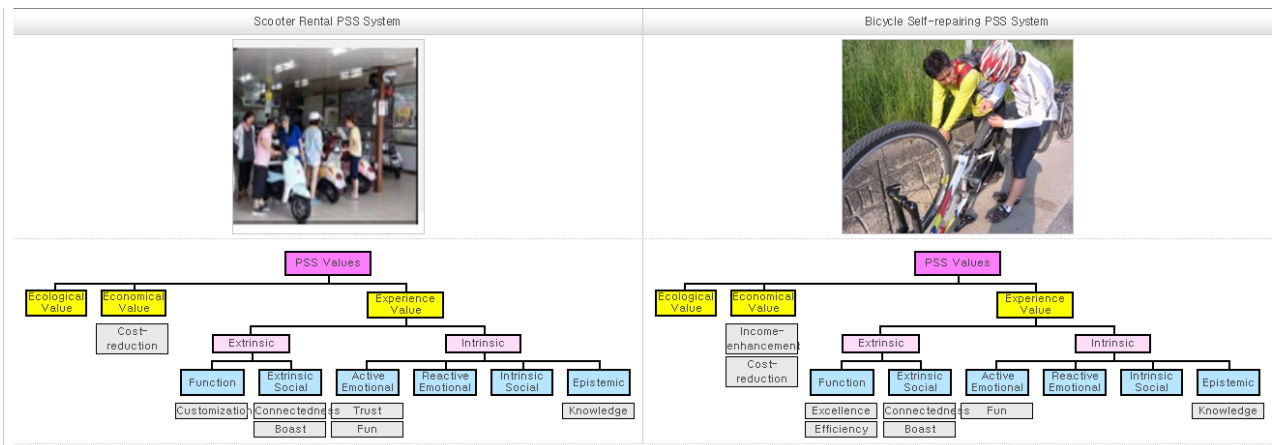


Figure 6. Value Space Comparison of Scooter Rental and Bicycle Self-repairing

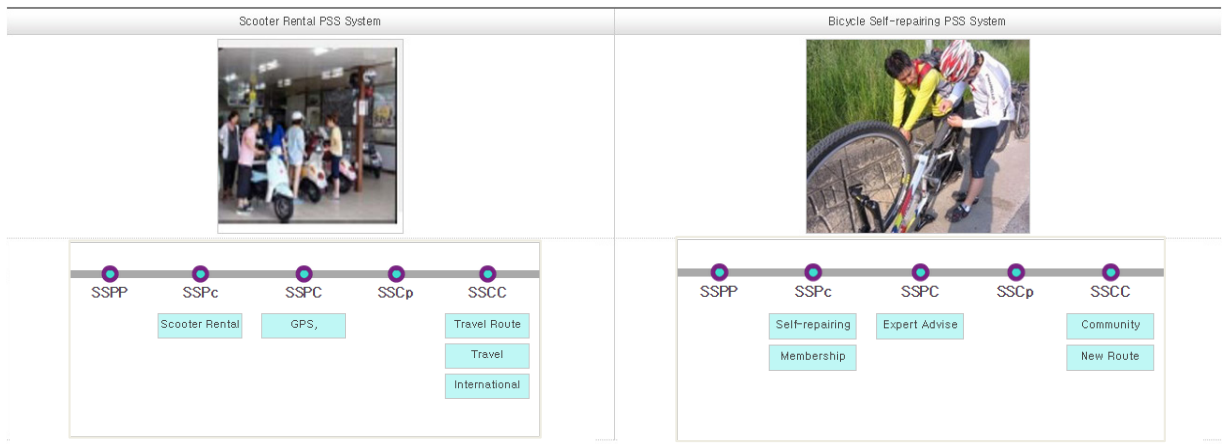


Figure 7. Service Space Comparison of Scooter Rental and Bicycle Self-repairing

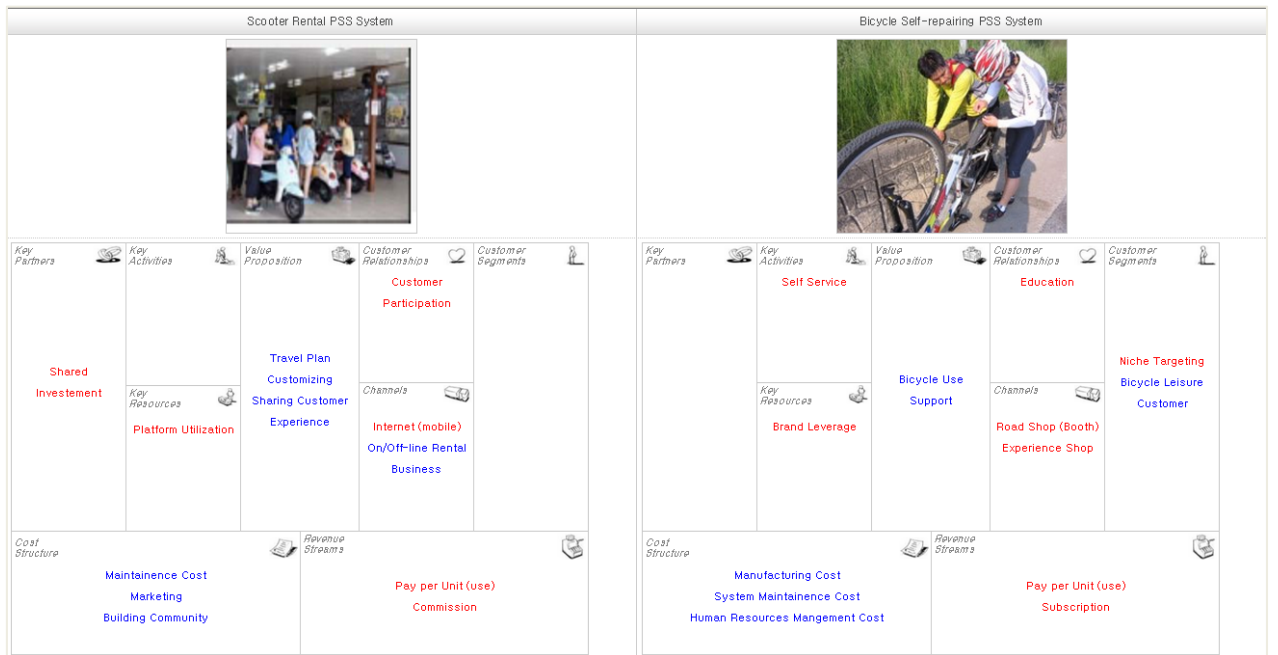


Figure 8. Biz Model Comparison of Scooter Rental and Bicycle Self-repairing

## 4 CONCLUSION

Service elements are integrated with product elements to provide diverse values in PSS. PSS vary a lot. Some have more product elements, while others have more service elements. Some services are to support products, and others are to support customers. A representation framework of PSS has been devised to support design process. A total of 12 dimensions are used to represent a PSS, including value space, service space, business model space, customer space and actor space. A repository of PSS based on the framework has been developed so that many PSS cases can be stored, retrieved and reviewed when a new PSS is to be designed. Similarities among difference PSS can be assessed based on the dimensions of the representation framework. A prototype repository with the proposed representation framework has been described with examples on how product-service design processes can be supported. The repository is being developed in the Manufacturing Servitization Support Framework consortium established with support from the Korean Ministry of Trade, Industry, and Energy.

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