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Note from the field

An approach to assessing sustainable product-service systems

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ABSTRACT

Academic interests in the product-service system have shifted from the area of environmental sustainability to the socio-economic issues. In this context, life cycle assessment is no longer the only approach to interpreting the performances of product-service systems. Multiple criteria reflecting product-service quality, customer satisfaction, and the full sustainability concerns would be needed to evaluate the system solutions. In this paper, a concept of sustainable product-service efficiency is proposed to explore the relationship between product-service value and the sustainability impact. Additionally, the authors discuss how this concept can be applied to assess sustainable product-service systems.

1. Introduction

The product-service system (PSS), as a business strategy, has great potential to generate solutions that fulfill industry and customer needs via the delivery of integrated products and services. The PSS makes use of a new service structure to facilitate sustainable production and consumption (Tukker and Tischner, 2006), and its effect is significant for developing countries that often engage in resource-consuming industries (Clark et al., 2009). Many studies have explored how PSS can create the advantage of environmental sustainability. Their contributions mainly emphasize the improvement in life-cycle management of products and the changes of consumption patterns (see Roy, 2000; Mont, 2002). However, to better meet social development and organizational innovation, the concept and strategies of PSS should go beyond the consideration of pure production/consumption issues. Regarding sustainability, the PSS needs a deeper engagement with social value and should address the context of socio-economic development (Ceschin, 2013). Thus, a new challenge for implementing the "sustainable product-service system" is to combine social sustainability into the visions and indicators of PSS design (Vezzoli et al., 2012). That is, to increase competitiveness via innovative offerings, companies should extend the scope of product-service solutions to the broader sustainability issues.

A number of studies have proposed approaches or frameworks for designing the PSS. They have mostly focused on developing the delivery system for product-service offerings and their efforts can be seen in the *Journal of Cleaner Production* and the *CIRP (College International pour la Recherche en Productique) Journal of Manufacturing Science and Technology*. The assessment of sustainable PSS is still in the relatively early phase and thus requires clear criteria to define whether a PSS is successful, or, whether it consists with the sustainability requirements. Dealing with this issue can facilitate empirical research on PSS, which is the trend of this field (see Beuren et al., 2013). To evaluate a PSS, the system perspective connecting the company, customers, and sustainability would be need. Although there is related literature contributing to this issue, several insufficiencies concerning the completeness of PSS evaluation exist, including:

- In service research, measuring service quality via customer perceptions/satisfaction has been widely used to explain service performances; nevertheless, the criteria of customer perceptions do not include sustainability concerns.
- Regarding sustainability assessment, the environmental impact can be clearly identified and is usually considered as the top criterion to interpret the PSS performance. In contrast, the social impact/value associated with PSS lacks clear definitions, often occupying a minor position in the PSS evaluation.

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- Employees are the channels to delivering product-service value; their organizational commitment can drive customer satisfaction and influence service performances. However, employee perceptions are usually ignored in the criteria of measuring product-service solutions.

Based on the above understanding, an index reflecting the comprehensive characteristics of sustainable PSS is required. Such index must be able to assess the PSS performance as well as to guide companies creating product-service value that positively meets sustainability concerns. As this issue is an emerging field of PSS, the theoretical basis should be built. In this paper, a concept of sustainable product-service efficiency is proposed to explore the relationship between product-service value and the sustainability impact. This concept is inspired by the eco-efficiency and is further extended to the social aspects and value perceptions of the PSS. To address the aforementioned insufficiencies and fulfill the evaluation of system solutions, the authors develop a hierarchical structure of multiple criteria for the specification of the proposed concept. Moreover, the authors discuss how these criteria become a metric for measuring sustainable product-service systems.

2. Transition of product-service systems

The PSS can be defined as a system that combines marketable products and services to meet customer demands (Goedkoop et al., 1999). This definition indicates that a PSS is composed of three key factors: products, services, and satisfaction. Thus, a fundamental question that companies must deal with is how products and services interact to generate satisfaction for customers and stakeholders. Several studies had identified three types of PSS: (1) product-oriented PSS, (2) use-oriented PSS, and (3) result-oriented PSS (see Cook et al., 2006; Williams, 2007). In the product-oriented PSS, customer satisfaction mainly comes from a feeling of convenience because the company creates feedback or added value (e.g., maintenance, repair, and home-delivery services) directly on products. As for the use-oriented PSS and the result-oriented PSS, customer satisfaction implies enjoying the function of products or the result of services rather than enjoying the product ownership. Regarding environmental sustainability, these PSS types can bring great benefits such as extending the product life cycle, changing consumption patterns, and reducing the total product and material use. In this context, evaluating the PSS performance is equal to measuring the environmental impact caused by product-service solutions. Life cycle assessment (LCA) is a traditional approach to implementing the evaluation task. However, as argued, the sustainable PSS should cover broader issues ranging from the environment to society and should reflect the need of socio-economic development. An increasing number of case studies have explored how social innovation can be incorporated into the PSS for sustainable development. For example, collaborative services introduced by Jégou and Manzini (2008) encourage people to build an interactive community that allows households and the neighborhood to share resources, create mutual assistance, and perform daily practices more easily. Involving the use-oriented PSS such as multi-user laundry or shared sewing studio and the result-oriented PSS such as home nursery, these solutions not only reduce people's financial burden and resource consumption but also improve social issues such as skill empowerment and home care (see Jégou and Manzini, 2008). In addition, a sustainable PSS constructed of the community, the company, and the local government can also facilitate synergistic community transformation and promote social development such as cultural tourism and youth employment (see Xing et al., 2013a).

Table 1 summarizes crucial components of the PSS, including product-service value and related strategies. Classic principles of the PSS demonstrated by earlier studies are shown in the left column; potential PSS solutions discussed in the newer literature are indicated in the right column. It shows that the potential types of PSS require social cohesion and emphasize the cooperation between companies and stakeholders. The customer satisfaction here is not limited to the context of product use; it encompasses other possibilities such as community participation or knowledge/information sharing. To boost sustainable innovation, companies should build collaborative networks along with customers and then identify their needs via such interaction (see Hofman and de Bruijn, 2010). At the moment, measuring the environmental influence is no longer the only approach to interpreting the PSS performance. More comprehensive criteria reflecting product-service value, the interaction between the company and customers, and the comprehensive sustainability requirements would needed to evaluate a sustainable PSS.

Table 1
Scopes and components of the PSS. Data are summarized from Mont (2002), Manzini and Vezzoli (2003), Jégou and Manzini (2008), and Xing et al. (2013a).

	Classic types of PSS	Potential types of PSS
Strategies	Rental business, home-delivery services, car-sharing schemes, etc.	Empowerment workshop, community building, resource sharing, etc.
Product value	Product durability, ease of use, universal design, etc.	New technology, customization, multiple functions, etc.
Service value	Added value (e.g., repair), feedback (e.g., discount), burden reduction, etc.	Education, synergy, welfare, etc.
Sustainability value	Life cycle extension, job creation, waste reduction, etc.	Skill empowerment, community transformation, human care, etc.
Factors of satisfaction	Cost saving, time saving, feeling of convenience, etc.	Knowledge acquiring, participation, sense of commitment, etc.

3. An approach to assessing sustainable product-service systems

3.1. Product-service value and sustainability assessment

A sustainable PSS means that product-service solutions should generate satisfactory value for customers and fulfill the sustainability requirements at the same time. Thus, product-service value and sustainability assessment are two essential criteria reflecting the performance of a sustainable PSS. Creusen (2011) stated that perceptual unity between products and services should be made such that customers can evaluate the PSS value with ease. That is, product-service value can be identified via customer perceptions of the quality of PSS offerings, which contain monetary and functional aspects (Xing et al., 2013b). Monetary value can be clearly defined and measured, e.g., via market price or the willingness to pay (WTP) (see Mestre and Vogtlander, 2013). In contrast, customer perceptions of functional quality of products/services are more complicated. Past studies have summarized several factors for capturing the value of products and services. For example, product quality can be evaluated according to the form/appearance and functionality/usability of a product and it covers aesthetic, symbolic, functional, and ergonomic considerations (see Creusen, 2011). The evaluation of service quality involves more behavioral issues and should consider the interaction between company/staffs and customers. The SERVQUAL model presented by Parasuraman et al. (1988) had outlined five dimensions of service quality, including tangibles, reliability, responsiveness, assurance, and empathy. Each dimension can be further divided into several quality attributes such as providing services as promised, giving