

Product-Service Systems across Life Cycle

# Exploring the critical factors for sustainable product-service systems implementation and diffusion in developing countries: an analysis of two PSS cases in Brazil

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## Abstract

This paper aims at exploring how some factors identified in the PSS and product/service innovation literature can hinder or foster sustainable PSS implementation in developing countries, since there is a lack of knowledge concerning the characteristics of PSS transition processes in different contexts. The identified factors were investigated empirically, through two PSS solutions located in an emerging economy. The main results demonstrated the role of some potential factors in supporting the implementation and diffusion of PSS solutions, especially those related to the involvement of multiple actors in the value creation and the social embeddedness. However, the role of those factors still need to be investigated in future works, since only two cases were analyzed in this research. Analyses of successful and unsuccessful PSS cases as well as the identification of other factors and characteristics of PSS implementation in different contexts are directions for further research.

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## 1. Introduction

Product-service systems (PSS) have been discussed as a promising opportunity for industries to propose both successful and eco-friendly solutions to fulfill consumers' needs [1]. With the focus on a satisfaction-based economy, PSS presents the potential for generating win-win solutions that promote profit, environmental and social benefits, and its effects can be significant for developing countries [2]. Indeed, PSS may act as business opportunities to facilitate the process of social-economic development in emerging and low-income contexts by jumping over or by-passing the stage of individual consumption/ownership of mass produced goods towards a 'satisfaction-based' and low-resource-intensive advanced service economy [3].

However, PSS business models have been mainly studied and implemented as eco-efficient opportunities in industrialized contexts, and there are still very few PSS cases from developing countries explored and analyzed in the

literature [4, 5]. Nevertheless, considering sustainability in all its dimensions and all types of contexts it is important to deepen the understanding of PSS as a promising approach to couple not only economic and environmental benefits but also the socio-technical dimension of sustainability [2-4].

Indeed, academic discussions of service innovation tend to investigate well-established economies, which appears insufficient because emerging economies have been growing at faster rates and these economies are a source of disruptive innovations in many fields [6]. In addition, research on transformative services could also make a valuable contribution to understand the social and ecological consequences of services offerings for developing economies [7]. Moreover, service research in those contexts is also necessary because the well-established theories and empirical generalizations derived from data gathered in the high-income segments could not always be applicable to developing markets [7]. The transition to PSS in different contexts remain a research gap, and there is a lack of knowledge concerning

the characteristics of the PSS transition processes in each context [4]. In this sense, this paper aims at exploring and discussing how some potential factors discussed in the PSS and service innovation literature can hinder or foster the introduction of PSS in developing contexts. The factors are discussed empirically through the analysis of two PSS solutions located in an emerging economy (Brazil), in order to better understand the extent in which they may affect sustainable PSS solutions implementation and diffusion. The paper is an exploratory study that aims to deliver some initial insights about the particularities of PSS implementation in developing contexts. The remainder of this paper is structured as follows. Firstly, a brief overview of PSS as sustainable solutions, especially for developing segments is presented, and the factors that are part of the theoretical framework of this study are discussed. Secondly, the research methods to identify the factors, to collect and to analyze data are presented. This is followed by an analysis of the two PSS solutions from the perspective of the identified factors. Finally, conclusions are drawn regarding the implications of this study, its limitations, and directions for future research.

## 2. Theoretical framework

PSS business models have been discussed as promising to achieve the sustainability [8] and many PSS cases have been discussed in the literature. However, in developing contexts the PSS concept is less emphasized when compared with a large number of empirical case studies from developed countries. Table 1 summarizes the papers from peer-reviewed journals identified in a literature review that explores PSS cases in developing countries.

Table 1. PSS case studies in developing countries.

PSS type	Country	References
Coffee association	Bolivia	Devisscher and Mont [5]
Bike sharing system	China	Zhang et al. [9]
Water purification system	Brazil	Sousa-Zomer and Cauchick Miguel [10]
Air compressor manufacturer	China	Xu et al. [11]

However, it is also important to understand how PSS concept is shaped in other contexts than the developed ones [5]. Innovation in services is a particularly relevant topic to explore in developing economies and bottom of the pyramid (BoP) contexts because innovative and productive services create new competitive sectors. Addressing challenges in BoP markets means to design new solutions that could be a driver for market transformation towards a more sustainable society by means of both clean technological solutions and changes in habits, favoring the efficient use of resources [13].

The literature has been stating that socio-cultural embeddedness is required to service innovation in BoP and developing contexts. Reynoso et al. [6] pointed out that culture might promote or hinder entrepreneurship, encourage or discourage risk taking, facilitate or prevent the integration of fragmented resources in emerging economies, or boost or interfere with service innovation. Some studies have also been

arguing that consumption choices are dependent on prior consumption patterns, and the diffusion of a PSS in the market is highly dependent on being sensitive to the culture in which it will operate [14]. In BoP and developing contexts, the most important factor of success is the willingness to understand what the local community need, responding to socio-cultural dimensions [15]. Micro-level challenges can be met only if the local context is well understood [16]. Culture is more relevant in emerging economies than for other segments because they often are governed more by social norms than by institutional instruments [6]. In this sense, cultural aspects of developing contexts may affect the implementation and diffusion of sustainable PSS offerings. Indeed, creating products and services for developing markets require a clear understanding of the needs and the context of the people within [15] and social embeddedness is thus required to design relevant services with local focus [16].

Moreover, it has been argued in the literature that governments can help to expand business opportunities by developing PSS-related policies and making them part of existing procurement policies, and by creating clear markets for companies' offerings [17]. New business models in BoP and developing contexts should feature balanced collaborations driven by different socioeconomic actors who can build on their complementary competencies to create value [16]. Furthermore, the literature states that there is a need for governmental support to disseminate knowledge about PSS [18]. In fact, customers may show a lack of knowledge and understanding about the PSS concept [14]. This must be even more emphasized in BoP contexts that consumers are deficient in skills and the education of consumers about products and services is a key factor [19]. The orientation of consumers about PSS can be valuable to help to change the consumption and production patterns. Knowledge may also influence the sustainability performance of the solutions in those contexts, also helping to avoid the rebound effects. Indeed, services in developing contexts results from the interaction between several actors and there is a need for a holistic implication of the network of actors in the co-creation process including active participation of the customers [16]. The diversity of actors in the co-creation process is essential to obtain value for all parts involved [16].

Technology has also been discussed as an inherent element of social innovation, providing reliable access to new services in BoP contexts [6]. Actually, BoP contexts offer the opportunity to study clean technologies such as renewable energies, water, and sanitation, which have the potential to disrupt traditional ways of delivering services [7]. Sustainable business models with a dominant technological innovation component may allow maximizing material and energy efficiency, for instance, through the dematerialization [20]. Product-service offerings with clean technological innovations may also be valuable in the context of developing countries as an environmentally sound path to economic development. Social innovations supported by new technologies and a clear understanding of the social needs and habits may help to solve societal problems [7] while it could provide environmental benefits. Next section outlines the research methods adopted in this research.

### 3. Research methods

A combination of research approaches has been used in this research. Firstly, a literature review was conducted and a theoretical framework was developed from the literature. Some PSS implementation aspects were identified in the literature as well as their relevance and how they must be addressed in developing contexts, as showed in Table 2. The critical aspects for PSS implementation discussed in the paper are not exclusively for developing countries, but in those contexts they have specific characteristics for PSS successful implementation, as discussed in section 2 and which are explored in the paper.

Table 2. Theoretical framework.

PSS implementation aspects	Relevance for developing contexts and/or how the implementation aspects must be addressed in those contexts
PSS implementation and diffusion in the market is highly dependent on being sensitive to the culture in which it will operate [14]	Services solutions should be focused on local community needs, responding to socio-cultural dimensions [15, 16] Consumers have low incomes and the offerings need to match the cash flows of customers and to be affordable for them, but it also should take into account other factors that affect customers (e.g. political and social) [15, 16]
Government can help expand PSS by creating PSS-related policies and creating market for companies offerings [17] Stakeholders may focus on building awareness and providing information to customers [15, 19]	Lack of private sector involvement, involvement of local stakeholders, policy and legal framework may be barriers to developing contexts [24] In developing contexts consumers may be deficient in skills and the education of consumers about products and services is a key factor [19]
A governmental support may help to disseminate knowledge about PSS [18]	
In eco-efficient PSS providers might be interested in the use of more advanced technologies [14]	Innovations with clean technologies have the potential to disrupt the traditional ways of delivering services in developing countries [7]

In order to refine the previously presented theoretical framework, a case study analysis was undertaken. Two PSS solutions that are the units of analysis of this study were selected due their sustainability potential for developing contexts. To select them, the strategies for selecting samples and cases proposed by Flyvbjerg [21] were followed. In an information-oriented approach, the cases are selected on the basis of the expectations regarding their information content. Both PSS are located in Brazil, a developing country, in different regions. The first one is a bike-sharing system, an effective alternative to sustainable mobility, since in the move towards sustainable consumption and production patterns mobility is one of the priority areas [9]. The second is a reverse osmosis (RO) water system that aims to deliver the result "purified water" for the population [22]. Drinking water provision represents a service with potential to improve human well-being, and it can be considered as an interesting empirical field for transformative services research [7].

These two heterogeneous cases (regarding business sector and companies size) were also selected in order to obtain a picture of the phenomenon and to analyze if both predicts similar results. They represent successful PSS solutions in the

analyzed region because they were well accepted by consumers, have sustainability benefits and have been helping to reorient the consumption patterns. Both business models are discussed in more details in the following section. In addition, the sustainable business model framework proposed by Bocken and Short [23] was adopted to analyze the business model elements of each PSS. This framework involves the following elements: (i) value proposition; (ii) value creation and delivery; and (iii) value capture.

Multiple methods of collecting data were applied. The sources of information were constituted by primary research data and/or secondary sources. Primary sources of data included semi-structured interviews with PSS actors (e.g. the service provider, business partners and consumers). Direct observations were conducted through onsite visits. Secondary sources basically included companies and business partners' websites in addition to scientific papers and other publications (e.g. companies reports). The collected data were analyzed, selected and reduced, and used for the cases descriptions. As already performed by Ceschin [8] a deductive approach was coupled with an inductive one in this study. Firstly, the theoretical framework was used to examine if the factors identified in the literature found a correspondence in the PSS cases (deductive reasoning). Secondly, the data collected from each case were used to identify relevant aspects related to the identified factors and how they could impact PSS sustainability performance (inductive reasoning). Next section outlines the main results of the analysis.

## 4. Results and discussion

### 4.1. Bike Rio system

The first PSS analyzed is the 'Bike Rio' system located in Rio de Janeiro. This system is considered a use-oriented PSS, according to Tukker [25] classification. The main goal of the Bike Rio system is to introduce the bicycle as a non-polluting and healthy public transport in order to combat sedentary lifestyles, to reduce traffic congestion, environmental pollution, and to promote social responsibility [26]. The system is an initiative of the city hall and is managed by a private company (a medium-size company). This PSS also has a private bank as a partner. The system comprises 60 stations with a total of 600 bikes, daily operating from 6 am to 12 am. Consumers can use a bicycle (available at the stations) for 60 minutes and after this period to return it to any other station. To make the registration and use of the bike the consumers must have a mobile phone to be used as an interface with the system (to use a bike they must call the company and inform in which station he/she will withdraw the bike and what are the position of the bike at the station). The payment is made through credit card. The rent for periods up to one hour is included in the registration fee. Other fees are applied when the consumer overextend one hour using the bike. There are also supporting vehicles that are used to transport bikes, perform maintenance, and to distribute the bicycles among the stations in case of larger imbalance.

Regarding bike-sharing systems as sustainable business models, the value proposition to the consumers and society

consists of providing a safe and affordable mobility option to complement public transportation system. The interests of the service provider, business partners and consumers are aligned because the former aims to contribute to the provision of a transportation option at an affordable cost for the latter (social value), while simultaneously earning profits from the rental service (economic value). For the environment, the system is aimed at providing a transportation alternative that allows pollution emission reduction. The products of the system were developed to have low energy consumption (the stations are powered by solar energy).

The value is created by the integration of many actors, i.e. the bicycles manufacturer, service provider, city hall, and other business partners (e.g. a private bank that is the sponsor of the system). The bikes are designed to be repairable and upgradable to minimize material consumption and new bikes production. The value capture is structured to allow more people, even those with fewer economic possibilities to have access to a transportation mode at a cheaper rate (the monthly registration fee is around US\$ 2.50). The small cost in comparison with other transportation options is an incentive for population use. In addition to environmental benefits, all actors have monetary gains with this system. The *Bike Rio* system is also part of a low-carbon development program launched at the Rio+20 Conference. The program is a partnership between the city of Rio de Janeiro and the World Bank, and it aims to accumulate carbon credits generated by the city programs to promote the sustainable development. The carbon credits will be sold on the international market in the future. Thus, in addition to environmental benefits, this PSS will provide economic benefits that will be converted into social investments in the city. So far, the system has accumulated 2,589.11 tons of carbon credits [26].

#### 4.2. Reverse osmosis water system

The second PSS analyzed is the RO water purification system. This system is considered a result-oriented PSS, and it involves the provision of the function “purified water” for the population of the southern region of Brazil [22]. According to reference [22], it represents an alternative to safe drinking water provision allowing to reduce the consumption of bottled water. The Brazilian company (the service provider; a small firm) acquires the RO equipment from a manufacturer abroad. The service provider signs a contractual agreement with some commercial establishments in the region, and the RO equipment is located in those establishments for population use. The actors share the responsibility for customer service. The profits are also shared and they are structured according to the customers’ service usage. The system operates as follows [22]: the equipment collects water from the public water network, and the water is purified by the RO process. To acquire the purified water, consumers go to the commercial establishments where the equipment is located. They bring their empty containers because the PSS does not provide any packaging. The service provider is responsible for the equipment installation, maintenance, replacement, and disposal. The value proposition for the population consists of providing safe and affordable water through the delivery of

“purified water.” The interests of the service provider and customers are aligned, because the former aims to provide safe drinking water at an affordable cost for the latter (social value), while simultaneously earning profits from the purification service (economic value). For the environment, the system is aimed at providing safe drinking water and consequently reducing the consumption of bottled water and the associated environmental effects. The equipment is aimed at the efficient use of water, low energy consumption, and low waste generation.

The value is created by the integration of the actors. According to the service provider, the equipment is designed to be durable, repairable, and upgradable to minimize material consumption, waste generation, and new equipment production. The commercial establishments have direct contact with the customers, which allow them to identify the customers’ needs and improve service quality. This relationship allows an effective management of the system. It also allows knowledge sharing and creates efficient communication between the actors. The technology employed in the equipment allows reducing the water waste during the purification process through a bypass system [22]. The value capture is structured to allow more people access good quality water at a cheaper cost than bottled water (the cost for consumers of purified water is about the half the cost of the same volume of bottled water). The reduced cost in comparison with bottled water is also an incentive for PSS use.

#### 4.3. Discussion of the critical factors for PSS implementation and diffusion in developing contexts

Concerning the contextual conditions related to culture, in both cases, it was observed that PSS solutions are well aligned with the community social needs (safer drinking water and mobility), local context and the solutions are offered to customers at affordable costs when compared to the traditional products and services. The economic and social needs seem to be drivers to the shift to PSS in developing countries [5], and these needs also represent a promising way to achieve environmental gains. Consumers have been using affordable solutions to satisfy their needs that are also less polluting solutions. In this sense, those PSS offerings focused on meeting economic and social needs were easily accepted and embedded in the context, and they also have been attracting consumers and helping to promote changes in their consumption behavior. The proximity to customers allows creating efficient communication and knowledge sharing, which incentives consumption behavior changes. In both cases, the use of PSS has been increasing on a daily basis (according to the service provider in the RO system [22], and according to the number of bikes usage so far - around 7 million usages according to the service provider report). However, PSS solutions must also be designed and developed focusing on the needs in according to the cultural values and based on how the practices to satisfy the needs are reproduced in the contexts. In the case of drinking water system, consumers in the region continue using plastic bottles in the PSS [22], since a proper reusable container was not developed

and there is a consumption pattern in that context associated with plastic bottles usage. To effectively drive changes in consumption patterns in the contexts where unsustainable trends exist and consumer reproduces a consumption behavior without realizing the environmental impacts it can cause (even more in the poor regions where population lack knowledge and education), the design of PSS solutions taking into account the contextual aspects are important for PSS successful implementation. Researchers and designers must engage with the local culture directly in order to better understand people and their context for the development of new solutions [15] that could be more sustainable than the traditional products and services. How different cultures and their particular values and norms could influence in PSS innovation need be better investigated in developing contexts, as already stated in the literature of service innovation [16], and this aspect could even influence the sustainability potential of the PSS as noticed in the case of the RO system.

Regarding the involvement of multiple actors on value creation and innovation process, concerning the governments that may help expand business opportunities by developing PSS-related policies and creating clear markets for companies' offerings, there are no policies to stimulate the adoption of PSS solutions in Brazil. In fact, PSS has not been formally integrated into the "action plan for sustainable production and consumption" [18], although some of the policies stated in the document can contribute to incentive PSS, such as the stimulus for the "creation and expansion of business and markets with social inclusion and less environmental impact", "sustainable public procurement", "innovation and diffusion of sustainable production and consumption technologies" [18]. In none of the analyzed PSS cases there are specific support policies and this factor could not be analyzed in the specific region. However, in the case of the bike-sharing system that is an initiative of the government (city hall) and private sector, the involvement of the public sector can be seen as a driver for the introduction and diffusion of the PSS. This initiative has created a business opportunity for new companies in the region.

The involvement of the city hall and the other business partners and the creation of the carbon credits program were noticed as a driver for the PSS to be embedded in the culture of the region. The system's use will create carbon credits that in the future will be converted to social benefits for the population. The population is part of the system because they will have benefits with the carbon credits sales. In this sense, in the case of Bike Rio, it was demonstrated that the involvement of multiple actors, including public and private sector could create market opportunities and facilitate PSS introduction. Governments can also create programs and policies that favor the sustainable development and incentive the PSS use and a reduction in the use of traditional products, in order to encourage changes in consumption patterns, having a major role in real sustainable solutions implementation and diffusion, especially in contexts where people lack education and knowledge. The private sector involvement was also noticed as essential for the solutions management. Previous experience in the water sector in the country, for instance, have demonstrated that isolated

government programs for the development of community shared systems that aimed to promote drinking water access for the population in semi-arid regions of Brazil were not enough. It is necessary to effectively manage the system in those regions, due to population lack of knowledge and experience. Governments play an essential role in promoting the introduction of innovations and sustainable solutions, but it is also necessary the complete involvement of the other actors as well, as already pointed out by Ceschin [8], and a deep understanding of how local communities are structured and how they build strong relationships [16].

The developing markets could be a lead market for developing clean technologies, as a means of gaining momentum when pursuing the disruptive technology path [7]. In addition, disruptive innovation and sustainability are considered to be complementary and reinforcing [7]. PSS offerings with innovative clean technologies such as the RO purification system and the solar panels to power the stations in the bike-sharing system offer the opportunity to innovate the entire business model and reorient the consumption patterns, as in the case of the RO system. The technology allows a more effective filtration process. In fact, technology has been helping developing contexts such as the Brazilian cities to develop new solutions and programs, but city leaders in these contexts need to be ready to support the sharing culture, which restates the role of government and multiple actors in supporting these business models. In addition, business models in developing contexts should be "inclusive", in order to transform population from being pure consumers into producers, entrepreneurs, or innovators [7], as in the RO system, an initiative to transform the way water services are offered to the population.

Concerning consumers' knowledge and education, the stakeholders need to focus on building awareness and educating customers in order to reorient the consumption patterns in developing contexts where a large part of the population may lack education. In Rio de Janeiro, the State Department for Environment has been promoting campaigns that highlight the benefits of bicycles as an alternative in order to reduce the number of cars. This also reflects the role of the government in supporting and disseminating knowledge concerning PSS solutions and its sustainability potential and the importance of local embeddedness. Other actors also have an important role in transfer knowledge to customers, especially for those that lack information in poor regions, since they are in contact with them. In the RO system the service provider and the commercial establishments provide information to the customer about water quality and the benefits of the system, but a more focused campaign with government involvement highlighting the environmental impacts of plastic bottles could be effective. However, the current economic policy in Brazil focuses on the expansion of product consumption as the primary development strategy, with various measures to motivate consumers to buy more goods [18]. This aspect also demonstrates the role of policies and government support for PSS solutions effective implementation and scaling-up, and how multiple actors, such as government, may affect sustainability performance of PSS.

## 5. Conclusions

This paper is an exploratory study and an initial investigation that aimed to discuss some particularities for PSS implementation and diffusion in developing countries. Since there is a lack of knowledge concerning the characteristics of PSS implementation and diffusion in different contexts, this paper aimed to contribute to PSS empirical body of knowledge.

The analysis of two PSS solutions in an emerging economy confirmed the role of some factors, especially those related to the involvement of multiple actors, e.g. government, through the creation of policies and business opportunities, and in helping to disseminate the PSS concept, because in low-income and developing contexts the part of population that lack knowledge and education may be high, and the transfer of knowledge about PSS may be promising for scaling-up the PSS concept. PSS solutions need to be carefully designed taking into consideration the cultural and contextual aspects, in order to conceive solutions that will be attractive, affordable for the population and with less environmental impacts. PSS design must also take into consideration the current practices of consumption and the development of business models should be an inclusive process, enhancing the role population not only as consumers but as part of the innovation process.

This study was limited to the analysis of two PSS solutions. In order to confirm the role of the identified factors for PSS successful implementation in developing contexts more cases need to be analyzed, involving both successful and unsuccessful cases. Nevertheless, there are still few business-to-consumer PSS cases in the context analyzed and also in developing countries, and for this reason only two cases could be analyzed in the region. In addition, since there are no specific policies that incentive the PSS adoption in the country, this aspect could not be investigated, although it could be a relevant factor for PSS diffusion in developing contexts where the focus may be on consumption increase from the economic development perspective. The identified factors were also explored in a unique context - an emerging economy - and future research should explore PSS solutions in low-income and other segments as well.

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