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Ángeles Pereira e Xavier Vence

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Grupo de investigación Innovación, Cambio Estrutural e Desenvolvemento (ICEDE)

Departamento de Economía Aplicada
Universidade de Santiago de Compostela
Avda. do Burgo s/n
15782 Santiago de Compostela – A Coruña
Telf. +34 881 811 567
www.usc.es/icede

Servitization and eco-innovation as drivers for sustainable business models

Ángeles Pereira Sánchez
Investigadora posdoutoral
Universidade de Santiago de Compostela
Telf. +34 881811701 angeles.pereira@usc.es

Xavier Vence Deza
Catedrático de Economía Aplicada
Universidade de Santiago de Compostela
Telf. +34 881811567 xavier.vence@usc.es

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Abstract

Servitization refers to the shift in the business model of a company from the sale of products to the provision of services or product-based services. The functional economy sees an opportunity to get eco-efficiency gains and to lead to dematerialised economies by means of servitization of companies. In this working paper a literature review is carried out in order to identify the potentials and challenges of servitization to become a useful strategy for driving sustainable system change. Firstly, the different approaches to servitization are presented. Secondly, the main theoretical approaches to eco-innovation and innovation for sustainability are summarised. The consideration of servitization as a sustainable business model is discussed, together with the insights gained from a sample of papers where environmental benefits have been identified.

Keywords

Servitization, eco-innovation, sustainable business models, system change

JEL codes: L14, O14, Q56

1. Introduction

Along the last few decades the world economy has been facing a structural change that defines a new socio-technical and economic paradigm (Vence, 2007). Amongst other factors, the growth of service activities, the development of Information Technologies and new activities, as well as the growing intertwining between manufacturing and service industries contribute to this change (Miles, 1993; Rubalcaba Bermejo, 2008). Behind it is the emergence of knowledge as a key resource of the new economic paradigm, which has led several authors to define present economies as knowledge-based economies (David & Foray, 2003; Foray, 2004; Foray & Lundvall, 1998).

The relevance of some service activities, and especially of those that are based on IT and knowledge, is due to their innovation capacity and to the dynamism that they foster in other activities (Boden & Miles, 2000; Miles, 1993). New service activities have achieved a great prominence on their own but one of the most relevant features of developed economies is the growing imbrication between service and manufacturing activities.

Services have been presented in manufacturing industries for a long time (e.g. transportation, commercialization, etc.) but the most recent trend is towards the fusion of services and products in the value proposal of traditionally manufacturing activities. Different types of services play a different role in supporting manufacturing, depending on the industrial life cycle stage. Kamp (2016) indicates that in the early or liquid stage, services are important to clarify the usefulness of new products and to get access to new customer segments. In the maturity level, services support manufacturing companies to increase their revenues and to satisfy new needs of customers. Finally, in the decline stage, services may support the necessary reinvention and new value proposals on behalf of the companies.

It is attributed to Vandermerwe & Rada (1988) the identification of servitization as a new global trend in manufacturing companies that reflected a total marketing strategy consisting in adding value to their core corporate offerings through services. Building upon this definition, marketing and management studies have studied servitization as an innovative strategy implemented by companies to achieve competitive advantages (Furrer, 2010; Oliva & Kallenberg, 2003). In any case, the attention paid to services relies on their innovative character and on the role of services as drivers for innovation in other different economic activities (Castellacci, 2008).

In addition, the important environmental challenges that the capitalist system is facing has created an increasing concern about the direction of innovation and about the effects that it causes in the society. Services may serve to create economic and social value. In this sense, some authors argue that, among other

factors, the sustainability challenge will be a key driver of future developments in service activities (Gadrey, 2010; Gallouj, Weber, Stare, & Rubalcaba, 2015). First, new services may be created on the basis of a new economic model, supporting primary and manufacturing activities that are organised in the local economy and the new needs appearing in that context. Secondly, services may be innovative and have fewer impacts in the environment by themselves.

From this viewpoint, the servitization strategy may be utilised by companies to achieve environmental objectives, which are beneficial for them and for their customers, and eventually for the society as a whole. Indeed Takeuchi (2013) argues that in the business strategy thinking, firms exist to improve the human condition and to create a better future. This statement means that "companies are not only focused on maximizing profit for shareholders, but also on serving the common good of its employees, its customers, its suppliers and other stakeholders as well as the society at large, including the environment" (Takeuchi', 2013, p. 9).

Within the field of environmental studies, some authors see servitization as a useful strategy to make progress in resource-efficiency and diminishing the environmental impact of economic activities (Beuren, Gomes Ferreira, & Cauchick Miguel, 2013; Mont, 2000a; White, Stoughton, & Feng, 1999). Building upon those assumptions, in this paper a literature review is carried out in order to contribute to the theoretical understanding of servitization as an innovation for sustainability.

In any case, the sustainability challenge requires system innovation, meaning changes in production and consumption patterns supported by a favourable socio-technical environment (Smith, Voß, & Grin, 2010). Servitization may be conceptualized as strategy that has a potential to achieve environmental and social gains; however, sustainability objectives cannot simply be met asking a company to change its business model. The companies' shift to the provision of services must be accompanied by other changes in the consumers and other agents, as well as institutions (Ceschin, 2013).

In this paper a literature review is carried out with the objective of contributing to the theoretical understanding of servitization as an innovation for sustainability. In the next section the drivers to servitization from the management and marketing literature are summarised. In the third section, the main assumptions that support the shift to product-service systems as a strategy that is good for the environment are revised. Next, the main theoretical contributions regarding eco-innovation, sustainable business models and social innovation are presented. The contribution of servitization to sustainability is discussed after the review of a sample of papers and some concluding remarks are offered.

2. The drivers of servitization in management and marketing studies

The marketing and management literature offers the main references to servitization as a strategy to improve the competitiveness of companies (Gebauer & Kowalkowski, 2012; Neely, 2008; Oliva & Kallenberg, 2003; Vandermerwe & Rada, 1988; Visnjic, Arts, & Ringov, 2015). From this approach, the motivations that guide manufacturing companies to swift to the provision of product-services are the need to halt the reduction of profits and to escape from the lack of differentiation trap (Chesbrough, 2011; Oliva & Kallenberg, 2003; Vandermerwe & Rada, 1988). In particular, it is stated that servitization allows companies to set barriers to competitors and others, to lock-in the customers, to differentiate the market offer and to diffuse innovations, as well as to get relevant information from the customers, which is needed to further innovation.

Additionally, other reasons that favour the offering of services are the greater financial margin and stability of gains along the economic cycle; the trend towards outsourcing in the market due to the need of flexibility and to the technological complexities that other organisations face; as well as the differentiation value of services (Oliva & Kallenberg, 2003; Vandermerwe & Rada, 1988).

According to Bryson (2010) services to products refer to the service functions that directly or indirectly support consumers in the acquisition and use of a product. Furrer (2010) specifies that "product services are services that are supplied complementary to a product to facilitate its choice and its purchase, to optimize its use and to increase its value for customers. For the firm providing them, they are a direct and indirect source of profit: direct because they are often more profitable that the product they surround and indirect because when expected by customers they induce demand for the product and are a source of differentiation on the firm's offering" (Furrer, 2010, p. 702).

Therefore, companies are mainly driven by commercial / financial objectives and the shift to servitization requires organisational and managerial changes. Following that, a great number of papers have focused on the conditions that may facilitate and hinder the development of services by companies (Gebauer & Kowalkowski, 2012; Gebauer, Paiola, & Saccani, 2013; Paiola, Saccani, Perona, & Gebauer, 2013).

There are some cases where, according to Furrer (2010) it is especially interesting for companies to choose a product-service strategy and move towards servitization:

a) In very unstable and saturated markets, with high competition;
b) When products are complex and require information and training for the customer;
c) When products need frequent updates;
d) When products are radically innovative;
e) When durable products require reparation and maintenance and when products are commoditites.

In the same vein, Kamp (2016) carries out a literature review and identify the following incentives for servitization:

f) The maturity of the sector implies the need for companies to differentiate and to add novelties to the base product;
g) In certain sectors and under certain circumstances, it is more profitable to take advantage of the installed base by adding services than to sell new product units;
h) In specific products, there is a need to find equilibrium between the acquisition expenditure and the life cycle costs of maintenance.

In such cases, manufacturing companies that decide to implement servitization strategies may achieve advantages such as: getting the loyalty of the customers and setting up barriers to competitors; escaping from commoditization and from cost-based competition strategy; having a differentiated / customised value proposal; acquiring a more strong and sustainable turnover along the time. However, the shift to servitization sometimes does not provide the expected benefits. Neely (2008) highlights important challenges for companies and the "servitization paradox", which refers to the fact that servitized companies may generate lower profits as percentage of revenues than pure manufacturing companies.

In this literature there is a lack of connection with the environment (Laperche & Picard, 2013). However, studies from the field of engineering and environmental sciences see product-service systems and the corresponding business model innovation as a strategy to drive economic activities towards a more sustainable fashion. This literature is revised in the next section.

3. Product-service systems and potential environmental benefits

One of the approaches to sustainable development is linked to the idea of the functional economy. In opposition to the industrial economy, which is based on the exchange of consumer products, the functional economy focuses on the exchange of value, i.e., on the provision of functions by products and technologies (Mont, 2000b). The environmental soundness of the functional economy is linked to the efficient use of resources. According to Stahel, a functional economy "optimises the use (or function) of goods and services and thus the management of existing wealth (goods, knowledge, and nature). The economic objective of the functional economy is to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible" (quoted in Mont, 2000, p. 27). Within this approach, product-service systems (PSSs) have been suggested as innovative business models with potential to reduce the environmental impacts of economic activities (Goedkoop, van Halen, te Riele, & Rommens, 1999; Mont, 2002a; White et al., 1999)

Mont (2002a, p. 239) states that a product-service-system should be defined as "a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models". The author considers that one of the main objectives of product-service systems should be reducing the environmental impact of consumption by:

- Closing material loops;
- Decreasing consumption through alternative scenarios of product use;
- Increasing general productivity of resources use and dematerialization of PSS;
- Providing system solutions.

The design of eco-efficient product-service systems sets the basis for re-thinking servitization as an innovation that goes further than economic gains for the companies and provides societal benefits. The potential contribution of servitization to environmental objectives has led some authors to speak specifically about eco-efficient producer services (Bartolomeo et al., 2003), sustainable home services (Halme, Jasch, & Scharp, 2004) or green servicizing (EPA, 2009).

Eco-efficiency gains and the freedom to design and commercialise a value proposition to the customer based on performing a function or providing a result, are highlighted as the main contributors to sustainability (Roy, 2000).

One of the main features of servitization is the change in the manufacturer role. Manufacturers move from the (design and) build of a product to build-operate-servitize the product (Kamp, 2016). In other words, PSSs require manufacturers or service providers to extend their involvement with, and responsibility for, the product to phases in the life-cycle outside the traditional seller-buyer relationship (White et al, 1999). In some cases, the manufacturers maintain ownership of the product; hence they have the responsibility for the whole life span of the product. This feature is the key to understand why the ability of product-service systems to achieve environmental improvements is commonly related to eco-efficiency gains (Mont, 2002b; Roy, 2000; White, A. L., Stoughton, M., Feng, 1999).

According to the World Business Council for Sustainable Development eco-efficiency "is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity." Four elements are importantly related to eco-efficiency: dematerialization, closing material loops, service extension and functional extension (Mont, 2004a).

There are several situations that create incentives for the producer to increase eco-efficiency in PSSs (Mont, 2004a; White, A. L., Stoughton, M., Feng, 1999):

- The producer's responsibility for the product is extended due to the maintenance of the ownership until the product's end of life. Thus, PSSs have the effect of internalizing use or disposal costs. Therefore, service providers have incentives to improve operation and reduce these costs.
- Sometimes the product has significant end-of-life value and the close relationship between producer, user and other actors along the supply chain supports the setting up of a take back system. In this case, the service provider finds incentives to carry out reclamation activities, such as recycling, re-using or re-manufacturing.
- The provision of the service turns the product into a cost rather than a source of profit. Therefore, profits have to be linked to the number of functional units that the product delivers. Service providers will seek to improve the operation and maintenance to extend product life, reducing the quantity of product required to deliver the service or increase the intensity of use.

Despite the recognition of the potential of PSSs to achieve sustainable aims, services in general and servitization in particular are not inherently more environmentally-friendly than conventional product-based business models (Plepys, Heiskanen, & Mont, 2014). Although services present a smaller ratio of material and energy per economic value of output than manufactured goods, they are to a large extent dependent on industry, and there are several sources of materiality, so this does not necessarily imply an absolute reduction in material consumption (Djellal & Gallouj, 2015). For those reasons, in order to promote servitization as a more sustainable business model and as a strategy towards sustainability, there is a general agreement on the need of designing and conceiving PSSs according to this goal. "It is only when a PSS actually assists in re-orienting current unsustainable trends in production and consumption practices that it can be referred to as a Sustainable Product-Service System" (Manzini & Vezzoli, 2002, p. 5).

Apart from some theoretical and tentative assessments (Goedkoop, M., van Halen, C., te Riele, H., Rommens, 1999; Tukker, 2004a) along the last few years, only a few papers have attempted to calculate the environmental gains of product-service systems. Before revising some of those papers, in the next section the theoretical underpinnings of eco-innovation are presented. Eco-innovation theory may be useful to understand servitization as a strategy for sustainability.

4. Eco-innovation and socio-technical transitions: theoretical underpinnings

4.1 What is eco-innovation?

The concept of eco-innovation was probably used first in the mid-90s although pollution control innovation, pollution control technologies or environmental innovation were used previously and also refer to similar (technological) issues. A broad definition of eco-innovation was offered by Rennings (2000), who referred to

eco-innovations as those "measures of relevant actors (firms, politicians, unions, associations, churches, private households) which develop new ideas, behaviors, products and processes, apply or introduce them and which contribute to a reduction of environmental burdens or to ecologically specified sustainability targets" (Rennings, 2000, p. 322). Thus, eco-innovation may be technological, organizational, social or institutional.

Based on the definition of innovation of the Oslo Manual (OECD, 2005), the MEI Project suggested a more specific definition: "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp & Pearson, 2007, p. 7).

The Ecodrive Project (CML, PSI, & CSM, 2008) defined eco-innovation as a subclass of innovation where the economic and environmental performance of society are improved at the same time. From this point of view eco-innovation is specifically the one which is able to meet a double gain, to provide a win-win situation. In the same view, within the industrial dynamics approach eco-innovations are defined as "innovations which are able to attract green rents on the market" (Andersen, 2008, p. 5). Hence, the double gain is emphasized, i. e., improving the environment along with businesses competitiveness.

The OECD (2009) set an eco-innovation typology on the basis of three axes: targets, mechanisms and impacts. The target is the basic focus of eco-innovation and may refer to products (goods and services), processes, marketing methods, organizations or institutions; the mechanism refers to the method by which the change in the eco-innovation target takes place or is introduced (modification, redesign, alternatives or creation); finally, the impact represents the innovation effect on environmental conditions and it depends on the combination of the innovation's target and mechanism. The change can vary from incremental as far as to the complete elimination of environmental harm.

From all of the definitions above some ideas may be extracted about eco-innovation:

- It is an innovation that positively affects the environment, whether it is a targeted or an unintended effect;
- It may be of technological and non-technological nature;
- It may be implemented and / or adopted by different agents;
- It represents a change, which may vary from incremental to radical impact.

Therefore, the potential contribution of eco-innovation towards the sustainability of the society may widely vary depending on the specific eco-innovation. Different theoretical approaches have been used to analyse eco-innovation and its potential with regards to sustainability. The next section provides an overview of them.

4.2 Eco-innovation from different theoretical perspectives

Most of the past research carried out in relation to eco-innovation has a focus on the firm level, especially with regards to the drivers and barriers to implement and adopt eco-innovation (see Pereira & Vence, 2012 for an overview). Within environmental economics, several authors have discussed the role of different types of policy instruments on fostering eco-innovation (Jaffe, Newell, & Stavins, 2002; Popp, Hafner, & Johnstone, 2011; Requate, 2005). Rennings (2000) indicates that environmental economics and innovation economics are useful to explain two peculiarities of eco-innovation: a) the double externality problem, which refers to the spillovers that eco-innovation creates both at the innovation and diffusion stages; b) the regulatory push/pull effect, which highlights the relevance of regulation to foster eco-innovation in comparison with conventional innovation.

Broadening the focus of environmental economics and thus overcoming the view that eco-innovation is a simple answer to a policy stimulus, evolutionist approaches study eco-innovation from a more systemic point of view. Evolutionist theories are more concerned with radical innovation, with changes in the long term and transitions from one technological regime to another new one. From this viewpoint, another key characteristic of eco-innovation is explained, namely the interactions between ecological, social and institutional systems (Rennings, 2000).

Co-evolutionist approaches also differ among them when considering eco-innovation. While sharing the view that eco-innovation may support the transition towards a greener economy, different analytical frameworks focus on different problems:

Sectoral systems of innovation pay attention to the interactive and learning processes between firms within a sector and innovation is usually seen as incremental change (Coenen & Díaz López, 2010; Malerba, 2002). Thus, eco-innovation may define a new sectoral path if greener products and technologies become the standard within a sector.

From innovation system studies, there are different components in innovation systems that may explain the success of (or lack of) greener systems, namely networks of firm capabilities, knowledge infrastructures and policy and market institutions. This perspective limits the analysis of green innovation systems to study how the alignment of the functions of the different system components favours the introduction of greener products and services into market (Smith et al., 2010).

It is argued that in order to promote a really sustainable pathway, radical and systemic innovations are needed. Thus, changing production and consumption patterns, which usually involve social and institutional innovations, are considered fundamental to the achievement of this aim (Smith et al., 2010). The systems innovation literature considers that a sustainable systems innovation can only be the result of purposeful changes that affect the entire production-consumption chain, its flows, its multi-level architecture, its institutions and structures, and the behaviour of the actors involved in it (Smith et al., 2010; Weber & Hemmelskamp, 2005). Thus, differently from innovation systems, the socio-technical literature focuses on the achievement of societal functions and highlights the importance of institutions besides markets in the transition towards a more sustainable system.

"Such systemic (or transformative) innovation is more likely to take place beyond the boundaries of one company or organization as it often requires the transformation, replacement or establishment of complementary infrastructures. […] One of the imperative conditions for such innovation is social and cultural change, adopting new values and behaviour both on the producer and consumer side" (OECD, 2012, p. 4).

The socio-technical literature has developed the multi-level perspective (Geels, 2004; Smith, 2006; Smith et al., 2010) as a specific analytical framework to explain how transitions to more sustainable economies take place and what the role for public policy must be (Coenen & Díaz López, 2010).

4.3 Sustainable business models: the link between eco-innovation and sustainable socio-technical systems

It has been suggested that there is a gap between the level of companies and the level of societies that is missed when sustainable innovation is studied. Boons and Lüdeke-Freund (2013) argue that the concept of business models may form the necessary intermediate link.

The business model concept has been studied from different perspectives along the last few decades; however a common definition is still lacking. Zott, Amit and Massa (2011) review the literature from the disciplines of e-business, strategy and innovation and technology management and identify four emerging elements of business models:

a) a business model is a new unit of analysis, which is focused on a focal company but whose boundaries are greater than those of the company;
b) the system level is emphasised to explain how companies do business;
c) the activities of a focal company and their partners play an important role in the several definitions of business models that have been proposed;
d) business models try to explain both value creation and value capture.

Based on a literature review Boons and Lüdeke-Freund (2013, p. 13) identify four basic elements of a business model and propose a set of normative requirements that would need to be met for successfully marketing sustainable innovations:

- The value proposition provides measurable ecological and / or social value in concert with economic value. Such values are temporally and spatially determined.
- The supply chain involves suppliers that take responsibility towards their own as well as the focal company's stakeholders. The focal company does not shift its own socio-ecological burdens to its suppliers. On the contrary, it actively engages suppliers into sustainable supply chain management.
- The customer interface motivates customers to take responsibility for their consumption as well as for the focal company's stakeholder. The focal company does not shift its own socio-ecological burdens to its customers.
- The financial model reflects an appropriate distribution of economic costs and benefits among actors involved in the business model and accounts for the company's ecological and social impacts.

Business models therefore may support the strategic marketing of innovative processes, products and services and at the same time, they can change the terms of competition by restructuring the value chain and generating new types of producer-consumer relationships, while altering the consumption culture and use practices. "The business model perspective is therefore particularly relevant to radical and systemic eco-innovation, including how business models and strategies can induce and help diffuse radical eco-innovation and enable systemic changes and transformation" (OECD, 2012, p. 6).

4.4 Insights from social innovation theories

Innovation is usually analysed as business innovation, as innovation aimed at making economic profits. However, innovation may also generate other effects and spillovers besides the economic ones. For instance, eco-innovation is an innovation that brings about benefits to the environment. Lately there has been an increasing interest in social innovation. Pol & Ville (2009, p. 15) state that "an innovation is termed a social innovation if the implied new idea has the potential to improve either the quality or the quantity of life" and point out as examples innovations conducive to better education, better environmental quality and longer life expectancy.

The objective of sustainability has to do with improving the quality of life. However, business innovation does not have to be social innovation and social innovation does not have to be led by business interests. Indeed, the literature on social innovation highlights the role of other agents different from companies in developing and implementing social innovation. For instance, Mulgan et al. (2007) identify social innovation with

"innovative activities and services that are motivated by the goal of meeting a social need and that are predominantly developed and diffused through organizations whose primary purposes are social" (Mulgan, Tucker, Ali, & Sanders, 2007, p. 8). This way, the authors set a clear divide between business innovation and social innovation. However, that does not mean that an important role may also be played by companies with regards to social innovation. In the view of Mulgan et al. (2007), while single individuals, groups and small organisations are responsible for generating new ideas, the governments, the NGOs and the companies are the agents best positioned to implement and upscale those ideas.

Djellal & Gallouj (2012) add to the literature on social innovation a particular link to service innovation. The authors argue that independently on the sector where innovation takes place, social innovation usually consists in service innovation to face socioeconomic problems.

Some scholars have study the social dimension of sustainability through servitization. Indeed, some authors argue that the success of PSS in transforming consumption patterns depends to a great extent on the inclusion of social and humanistic dimensions. "By focusing only on increasing the responsibilities of producers, many initiatives have remained only isolated solutions, modifying the channels of service provision rather than offering holistic programmes working at the system-level" (Briceno & Stagl, 2006, p. 1549).

Eco-innovation and social innovation share some commonalities. The double externality problem highlighted by Rennings (2000) explains why there is underinvestment in innovation with large ecological and societal benefits. For that reason, the author claims for the necessary regulatory push/pull effect in order to enable eco-innovation.

5. Servitization: potentials and challenges of innovation for sustainability

In spite of the existence of a general agreement on the potential of product-service systems to achieve sustainability aims, what is lacking is a definition of servitization as eco-innovation or as an innovation towards a sustainable business model.

Carrillo-Hermosilla, Del Río González, and Könnölä (2009) characterize eco-innovation according to different dimensions, namely design, user, product / service business model and governance. Regarding the product / service dimension, the authors identify two types of changes that refer to the functions attributed to sustainable business models:

a) Change in product service deliverable: it is characterized by changes in the product service delivered and by changes in the perception of the customer relation;

b) Change in value networks and processes: it means changes in the value-networks (value-chain and other relations) and processes which enable the delivery of the product service.

In the classification of the OECD (2009) the adoption of new business models such as PSS is defined as a kind of marketing eco-innovation, based on the change in the way products are priced, offered and promoted. When eco-innovation is classified according to scope, the OECD refers to product-service systems as a potential radical innovation. "Radical innovations could include not only the development of radical, breakthrough technologies but also to a reconfiguration of product-service systems […] and to the development of business models that reshape the way consumers receive value on the one hand and reduce material use on the other." (OECD, 2012, p. 4).

The literature revised in section 2 above indicates that servitization may be conceptualised as an innovation in the business model of manufacturing companies. Servitization does not represent a product or service innovation although technological innovation may be necessary to make it possible. The shift to servitization requires changes in production processes and also a different behaviour on behalf of the customers.

Servitization implies a change in the product / service delivered and also a change in the value chain that enables the delivery of the product / service. Servitization implies a new producer-consumer relationship: putting the customer needs at the centre requires new processes and a different perception of the buying and selling relationship. Hence, servitization involves a greater responsibility of the provider and a closer relationship with the customer. In this way, servitization creates incentives for the introduction of improved products and services with which the provider fulfils the client's need in a more efficient manner. Thus, servitization represents a new way of creating value for customers and capturing value by companies.

Thus, servitization may be defined as a new business model, meaning a new way of providing and capturing value. A greater challenge is to promote the eco-innovation of servitization or the design of servitization as a sustainable business model. Mont (2004b) argues that the main components of product-service systems (products, services, infrastructure and actor network) need to be supported by a systemic view of sustainability, that she translates into competitiveness and economic viability for businesses; customer acceptance and added value to customers; and reduction of life cycle environmental impacts. Contextual elements such as the organizational layouts, the institutional framework and the cultural context are important to favour PSSs to succeed.

As already mentioned in section 3, some scholars argue that PSSs represent a specific type of sustainable business model. In particular, there is a large research about Energy Service Companies (ESCOs), which are presented as a type of sustainable PSS based on the servitization of energy companies and that can support a

wider socio-technical transition (Bolton & Hannon, 2016; Ceschin, 2013; Hannon, Foxon, & Gale, 2011). However, there are different types of PSSs and therefore, their contribution to sustainability is an arguable question.

On a theoretical level, Tukker (2004b) sets several differences. For the author, result-oriented PSSs offer a greater degree of freedom to the producer for designing and offering the most effective solution. Thus, they are expected to achieve the greatest reduction of environmental impacts. Outsourcing and activity management may drive greater benefits if efficiency gains are related to materials and artefacts, rather than human resources. Pay per use PSSs may achieve incremental improvements but they require a technological system change to drive more radical gains. Other types of PSSs probably get minor improvements. For instance product-based PSS, which usually consist of adding advice and consultancy services to products, and product-use PSS, such as leasing and sharing schemes, may just marginally reduce environmental impacts. Leasing and sharing assets may have important reductions if impacts are related to the production stage rather than to the usage phase.

On a theoretical level, some papers have just assumed the contribution of PSSs to sustainability. Other papers have studied the relation between the shift to servitization by manufacturing companies in relation to regulatory environmental constraints and the impacts in innovation management (Laperche & Picard, 2013).

In this last section we make a review of a small sample of papers, which have been selected because they offer quantification –from real cases or estimated cases, of at least one type of effect with regards to environmental sustainability. A summary of the papers is provided in Table 1.

All of the PSSs analysed are very different in scope, ranging from isolated solutions to system-level solutions. Thus, some of the papers study a focal company and its customers, while others consider, besides a focal company, other partners, including private companies, public agencies and groups of targeted consumers. Lastly, there are two examples of agricultural cooperatives, which are different because in these cases, the farmers decide to join in this type of association in order to share some assets and services.

Table 1. Literature review: contribution of product-service systems to sustainability

Reference	Product-service-system	Stakeholders	Sustainability achievements
(Komoto, Tomiyama, Nagel, Silvester, & Brezet, 2005)	Comparison of alternative models of the washing function: traditional model, functional sales, shared use and commercial model	Service producers Service receivers	Dematerialization in sharing and commercial use models; Re-use of modules; Low total cost if efficient use
(Lindahl, Sundin, & Sakao, 2014)	1) Core plugs for paper mills 2) Cleaning of building exteriors 3) Soil compactors services	1) Service provider and customer 2) Service provider and customer 3) Soil compactor manufacturer, rental company and customer	1) Re-use and recycling of materials 2) Detergent savings; Intensive use of machinery 3) Greater leasing of soil compactors; Increased knowledge to reduce maintenance requirements
(Lelah, Mathieux, & Brissaud, 2011)	Machine-to-machine network for information gathering in routes of waste glass collection	M2M provider Local council	Collective use of infrastructure; Protocols for implementation, maintenance and disposal of
(Evans, Partidário, & Lambert, 2007)	La Fiambrera. Food delivery service for elderly people supported by social services and for employees of SMEs	A meal production company A software company Local social services Local market traders Users (SMEs employees and elderly people)	Reduction in energy consumed for heating, storage & cooling, and preparation; Reduction of water consumption; Reduction of transport; Reduction of food waste; Economic costs savings; Social benefits
(Devisscher & Mont, 2008)	Cencoop. Cooperative that provides services to coffee producers	Coffee producers Cencoop NGOs Certifiers National and international retailers Consumers	Sustainable agriculture (training, technical advice, seminars); Shared use of equipment, professional management and maintenance; Better waste management; Access to financial resources to comply with environmental standards
(Lee, Geum, Lee, & Park, 2012)	Public bicycle system	Local government Bicycle users Bicycle retailers Bicycle system operator Bus companies	Long term impacts derived from the transportation shared use: environmental impacts, users' health, transportation and health policy costs
(Pereira, Carballo-Penela, González-López, & Vence, 2016)	Farm machinery, heifer breeding and fodder production and delivery services by agricultural cooperatives	Agricultural cooperatives Dairy farms	Eco-efficiency improvement: reduction in the number of CO2 eq. in relation to milk production

In the Table 2 we have tried to identify for each of the product-service systems analysed, to what extent they depend on the servitization of a company and on the adoption of eco-innovation. In the last column, the key aspects of success in terms of environmental performance as identified in the papers, are presented.

In all of the cases, some environmental gains are achieved. The use of different methodologies and indicators to quantify these gains makes it difficult to set comparisons between the cases. However, it is possible to identify a number of factors that facilitate success in terms of environmental performance, namely: the introduction of eco-innovation (eco-design, improved products and / or services, business practices); coordination of supply and demand through a close relationship between providers and users; shared use of assets (mutualisation of assets); a collective shared vision about the system.

Table 2. Servitization dependency

Product-service-system	Servitization role	Eco-innovation role	Key aspects of success in terms of environmental performance
Washing function: traditional model, functional sales, shared use and commercial model	A manufacturer in the case of functional sales	Increase performance of the lifetime critical module	
	A service provider in the sharing model	A community washing machine	Balance of total service supply and demand; A third party providing infrastructure to facilitate effective usage; Feasibility at service providers and receivers
	A service provider in the case of commercial model	A professional washing machine	
Core plugs for paper mills	A manufacturer offers products leasing	Process to transform plastic waste and food fibres into cheap, recyclable and moisture-resistant composite material Reuse system Recycling system	Higher commitment of the PSS provider during the life cycle of the products: engineering activities (recycling, remanufacturing, reuse, maintenance, holistic planning and operation); Flexibility to develop innovative technology; Close relationship with relevant actors
Cleaning of building exteriors	A service provider offers cleaning services / rental of cleaning equipment to service companies	Qlean water® - method to purify tap water; QW equipment (tools to facilitate the cleaning of facades); Application method	
Soil compactors services	A manufacturer supplies spare parts, technical service and support; pure service agreements with different levels to choose	Remanufacturing and maintenance; Smart design of soil compactors	
Machine-to-machine network for information gathering in routes of waste glass collection	A service provider of machine-to-machine (M2M) services supports a local council	Eco-design of the networks of sensors and their corresponding communication modules and gateways (energy supply and electronic components); Mutualisation of the M2M platform with other services	Key system-design of technical parameters: cleaner technologies (energy supply technology; quantification of data transferred); Business and organisational parameters: mutualisation, better organization of installation, maintenance and dismantling and closely coordinated action between actors providing different services
La Fiambrera. Food delivery service for elderly people supported by social services and for employees of SMEs	A meal production company delivers healthy food to new markets	Dematerialized marketing channel Improved logistics	Innovative partnering with organisations that have some influence over the last stages of the product-life; Private-public partnerships
Public bicycle system	A public bicycle system operator	Share transportation mode	Hypothetical case: greater environmental gains as far as the share transportation mode becomes spread
Cencoop. Cooperative that provides services to coffee producers	A cooperative of 5 coffee cooperatives works as a centralised facility for coffee collection, processing and marketing and provision of services related to production practices of farming	Research and promotion of eco-sound production practices; Optimisation of processing equipment through improved technology and skilled personnel	Shifting from individual to collective processing; Shared ownership of processing equipment; Collaboration with different stakeholders; Institutionalisation of the system Collective visions
Farm machinery, heifer breeding and fodder production and delivery services by agricultural cooperatives	Three cooperatives integrated by single and partnerships of dairy farmers provide common services regarding machinery, heifer breeding and fodder needs of dairy farmers	Shared use of facilities and machinery; Improved logistics	Shifting from individual to collective breeding of heifers, collective processing of fodder and shared use of machinery; Economies of scale; Collective visions

6. Discussion and concluding remarks

An extensive literature review has been carried out in this paper with the aim of contributing to the academic debate regarding the potential of servitization to support a system change towards sustainability.

It is clear that servitization is primarily a business innovation that defines a new trend in business operations and strategy. The offering of services besides products or instead of products may contribute to achieve competitive advantages for companies due to the features of services and the growing interest of markets in flexible solutions, rather than in the ownership of products.

Following some scholars from the field of eco-innovation, going ahead of the environmental challenges (for instance anticipating to stricter environmental regulations) may give competitive advantages to companies (Lanoie, Laurent-lucchetti, Johnstone, & Ambec, 2011; Porter & van der Linde, 1995). For this reason, it is possible to argue that servitization may help companies to make environmental challenges a source of competitive advantages.

However, the capacity of servitization to drive sustainable system changes cannot only rely on businesses. As it is suggested by the evolutionist approaches of eco-innovation, system solutions require major changes in production and consumption patterns, new infrastructures, involvement of various actors and wide institutional support.

In this sense, the results obtained from selection of cases presented in section five set the basis for discussing the challenges of companies to achieve sustainability aims through servitization. The papers present various cases of product-service systems, which are very different from each other, especially regarding system boundaries. Firstly, companies, especially manufacturing ones, are considered the most influential actors in designing and realizing application of PSSs. The cases that have been revised allow us to confirm that companies (and also cooperatives in the agricultural sector) have a key role to play in the design of sustainable product-service systems. Those cases indicate that an important challenge for companies deciding to eco-innovate their business models is related to design issues. And this refers not only to the design of a specific product / service but to the design of the whole system, or the business model, in order to set necessary partnerships and coordinate the supply with the requirements of the demand.

Secondly, although the servitization of companies may be useful to drive a sustainable change in the economies, it is clearly insufficient. The cases that have been revised indicate that there is a need for cooperation between different stakeholders in order to get a result that is beneficial for the society at large while being attractive for both, producers and consumers.

Thirdly, the literature offers examples where product-service systems do not rely on private companies but on social processes. The role of governments and social communities is necessary to address the change in consumption patterns. The case of La Fiambrera (Evans et al., 2007) that is included in this paper is a good example of how the design of a product-service system and its potential to succeed, meaning an achievement of benefits for all of the participants –with their different visions and beliefs, and the society at large, require the partnering of all of them.

In this sense, other works have highlighted the key role of the members of a community and social motivations(community building, convenience, environmental awareness) in the implementation of product-service systems (Briceno & Stagl, 2006).

With this work we suggest that the usually assumed potential of product-service systems to minimise environmental impacts while maintaining the economic performance of companies needs more empirical research. The growing trend towards servitization is not necessarily driven by eco-innovation objectives or by the aim of constructing sustainable business models but by economic objectives instead. Hence, in the best of cases, companies may get reduced environmental impacts as an unintended effect or as a supplementary effect that is linked to economic gains. However, as has been highlighted in the literature, those environmental gains may represent just an isolated solution.

As pointed out by eco-innovation and social innovation scholars, the achievement of societal objectives such as it is the improvement of the environment, requires changes in production and consumption patterns. The role of institutions in this sense is to push and to pull the changes to happen. Firstly, policy support is needed to guarantee that social and ecological benefits are achieved at a system level; secondly, systemic and radical change cannot be the sole responsibility of companies, since new infrastructures and new partnerships are necessary to achieve societal objectives; and thirdly, this type of innovation requires changes on the behaviour of companies and individuals, hence both must consider that servitization is attractive in comparison to business as usual.

Nevertheless, in line with existing evidence and with the view of Takeuchi (2013), we insist on the opportunity for companies to make environmental issues a driving factor of their innovation strategies. Companies should pay attention to emerging services that may be the mainstream in the future.

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