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Towards sustainability: PSS, digital technology and value co-creation

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Abstract

This paper is a conceptual paper based on the method of literature review and case study (second-hand data). The paper has three aims. First, it tries to discuss the correlations between PSS and other terms that contribute to PSS development in the last four decades. Following the literature review, a chronicle chart of PSS development is compiled to link PSS with these main terms, environmental sustainability and digital technology. Second, it intends to explore the impact of digital technology on PSS and sustainability. Third, it aims to develop a conceptual framework, in which all PSS actors including suppliers, integrators, customers, end users and the society co-create value for a sustainable economy facilitated by digital technology. There are two main contributions of this paper. One is that it is the first time to compile such a PSS chronicle chart to show the correlation. The other is that the framework embraces the idea of oneness between product and services, functional fulfillment and social needs, and economic growth and sustainability that call for value co-creation. The framework can serve as an education model and practice guide for academia, industry practitioners, policy makers and non-government organizations (NGOs).

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1. Introduction

From 1970s, the environmental movement grew as consumers became more conscious of the environmental impacts of the products they were buying. There was a call of decoupling material flows from economic flows. Then globally, the United Nations Conference on Environment and Development (UNCED) was held (known as the Rio Summit) in 1992. Entering the new millennium, several influential concepts have been developed further, such as the Functional/Performance Economy, Blue Economy and Circular Economy [1–3]. For example, the Circular Economy was introduced as an alternative of the traditional linear model of ‘make, use, dispose’ and aims to keep products, components, and materials at their highest utility and value, for example, by providing services such as maintenance, refurbishment, remanufacturing, reuse and recycle.

Meanwhile, the leading position of traditional manufacturing has been substituted by service sectors in the developed countries. It is claimed that the growing service

components in a total offering can bring higher revenues [4–6] and competitive advantages to manufacturers [7,8]. It is also considered more environmentally sustainable than pure product manufacturing [9,10]. For example, in some cases, they replace physical products with ICT [11] or software [6].

As a result, there is growing interest in the shift from pure product sells to a product plus service offering. Many terms were put forward, including Eco-Efficient Services (EES) [12,13], Dematerialisation [14,15], Functional Sales [16], Servitisation [17,18], Servicizing [11,19], Product-Services Mix [20], Product-Service System (PSS) [21–23], Integrated Solutions [24], ‘Combining Products and Services’ [25], Hybrid Offerings [26], Integrated Product-Service [27], and most recently Digitalised PSS [28], and Smart Connected Product [6].

Accompanying this shift, the meaning of ‘value’ has been evolving from a pure monetary term [29], to a broader concept that embraces non-monetary element. For example, the relationship value [30] that focuses on customer relationship rather than transactions; the sustainable value that considers the

economic, environmental and social aspects [31,32]; the shared value that recognizes the societal needs [29]; and the value pyramid that has powerful emotional and social impacts in addition to the functional element [33]. The value creating process is also changing from the ‘value chain’ that has sequential value-adding activities [34] to the ‘value constellation’ [35] and ‘value network’ [36], where different actors simultaneously contribute to the value creating process. In essence, all these concepts call for value co-creation among PSS producers, customers, end users and the society. However, there is a significant lack of guiding models or frameworks of value co-creation in the PSS research, which forms the motivation of this paper.

Thus, the objectives of this paper consist of three parts. First, it aims to link PSS with other main concepts and then compile a chronicle chart of PSS development that also encompasses other similar terms. Second, it intends to explore the relationship between PSS, sustainability and digital technology. Third, the paper attempts to develop a conceptual framework in which all PSS actors co-create value (and sustainability) that is facilitated by digital technology.

2. Research Methodology

The research starts with a literature review that includes three parts. The first part explores different terms broadly and the search keywords include those terms mentioned in paragraph three of the introduction section. The second part focuses on environmental sustainability and digital technology and key words include PSS, environmental sustainability, digital technology and Information and Communication Technology (ICT). The third part explains the emergence of value co-creation in PSS that considers a broader value of economy, environment and the society and key words include value co-creation and ICT. The databases are Google Scholar and EBSCO Discovery Service (EDS) that can provide a broad search and identify high quality, peer reviewed papers. Lastly, a conceptual framework of value co-creation in PSS is built from case studies by second-hand data (e.g. company websites and reports).

3. Literature Review

3.1 Introduction of the main terms

3.1.1. Eco-Efficient Services (EES)

The concept of eco-efficiency was first introduced by Schaltegger and Sturm in 1989 [37]. At the Rio Summit 1992, eco-efficiency was endorsed as a new business concept for companies to achieve sustainability. Eco-efficiency aims to create more value with less impact, which can be achieved, for example, through selling the functional needs or additional services that customers actually want [38]. The interest in eco-efficient services (EES) arose as a research topic after the first EES Workshop was held in Germany in 1994. The World Business Council for Sustainable Development (WBCSD) defines EES as ‘a certain product-service mix which has a higher added value and a smaller environmental impact

compared to a similar product-service mix or a situation in which the activity was not performed at all’[38].

3.1.2. Dematerialisation

Dematerialisation aims to de-link economic activity from its material base, thus enabling economy growth while decreasing the use of natural resources. Dematerialization promotes efficient use of material and energy, and thus it focuses on the input side of society’s material and energy use rather than the output side [14]. It is believed that the potential impact of digital technology and ICT on dematerialization is huge in reducing transport of physical goods[11] or replacing the physical goods with electronic means such as an email instead of a paper letter and mp3 file instead of CD, etc.

3.1.3. Functional/Performance Economy (Sales)

A functional economy, as defined by Stahel [1], is one that optimizes the use or function of goods and services. It aims to create the ever-possible long-lasting use value by consuming as few material and energy as possible [1]. The functional sales concept is such a shift to the functional economy that combines the sale of a function or solution with the services of take-back and reuse [11]. For example, Electrolux and Xerox provide consumers cleaning services and document services respectively instead of selling washing machines and photocopiers. It is therefore considerably more sustainable than the present economy [11].

3.1.4. Servitisation (Servicizing)

The term of ‘servitization’ was first coined in 1988 by Vandermerwe and Rada [17] as the market offering of bundles of goods, services, support, and knowledge to add value to core products. In 1999, White et al. [11] submitted a report to the U.S. Environmental Protection Agency, where the authors used the term ‘servicizing’ to describe the growing product-based services. They called it ‘servicizing’ in order to emphasise that it is a dynamic state of change both for enterprises and products. Rothenberg [19] conducted 3 case studies including Xerox and concluded that in the ‘servicizing’ approach, companies make profits by helping customers achieve their goals while using less products. Recent research progress on servitisation include the work by Baines et al., Lightfoot et al., Smith et al., and He et al., etc. [18,39–41].

3.1.5. Product-Services System (PSS)

The first report on Product Services System was submitted in 1999 by Goedkoop et al. [21] to Dutch Ministries of Environment (VROM) and Economic Affairs (EZ). The research showed that PSS can decrease environmental load, bring additional eco-benefits and increase the quality of the contacts with clients. Then in 2000, the world 2nd PSS report was submitted by Mont [42] to Sweden Environmental Protection Agency (EPA). The report pointed out that there is a lack of research on indicators of PSS environmental performance and little is done about its data collection systems.

It is interesting that both reports (indeed three reports including the one above on ‘servicing’) were supported by the national governments of environment, from which we may see the early efforts made to environmental sustainability.

Despite much research on PSS, there are different definitions and understandings of PSS. As Sakao [43] pointed out that the lack of a shared terminology will hinder learning, sharing and knowledge building. In this paper, we define PSS in a broader way that not only embraces the homogeneous terms such as product-service mix but also other similar concepts such as Eco-efficient Services and Servitisation.

Since 1999, PSS has become a main research stream, esp. in Europe. This is illustrated in Figure 1. It seems all the major concepts converged at the point of 1999. There is a three-stage development of PSS. In the early stage, it was highly linked with environmental sustainability (as explained above). There was a steady increase in PSS research between 1999 and 2004, then followed by a drop [44]. From 2006, it increased again [45]. However, the domain of the papers shifted to a focus on the commercial side of PSS, with a leading trend from Harvard Business Review and MIT Sloan Management Review in the US. Since 2014, there has been a dramatic increase of PSS research that integrates digital technology. For example, the digitalized PSS [46] and ‘smart connected product’ [6,47]. It is also clear that the three waves of EU funded program (DX XII, SusProNetProject and H2020 PSS) have contributed to PSS development significantly.

3.2 PSS and environmental sustainability

Regarding environmental sustainability, many authors agree that the shift to PSS could bring in positive environmental effects [9,11,10,19,48–51]. This can be achieved in several ways. For example, first, by integrating PSS with companies’ environmental strategy. Companies such as DuPont, IBM and Xerox have led the way of replacing products with services as an integral part of their environmental strategy [11]. Rothenberg [19] found that by doing so the new business model not only helps existing customers to use less of products for an environmental benefit but also attract new customers that are impressed by the company’s social consciousness. Second, by linking the shift to PSS with the social, cultural, and organizational change. For instance, if manufacturers own the product and are responsible for its update, maintenance and recycle across the product lifecycle, there will be a financial incentive for them to design and make more durable products with less maintenance costs and longer service life and to reuse or recycle as many parts as possible [11].

On the other hand, some authors argued that PSS does not necessarily bring environmental benefits [22,43,52]. For example, Tukker [22] claimed that although most PSSs could probably bring environmental improvements, the assumption that PSS will intrinsically lead to a dual-win of environmental and economic benefits seems to be a myth. Sakao et al. [43] found companies shifting to services with business motivations do not realize the environmental potential. This is also

supported by Sundin et al., [53] who argued that sustainability is not always the main reason for the shift.

3.3 The emerging digital technology and sustainability

Melville [54] asserted that information systems greatly influence organizations’ beliefs and affect their actions concerning environment sustainability. With recent development of digital technologies such as ICT, IoT, augmented reality and social media technology, an integration of digital services with the physical products is emerging. For example, German manufacturers are increasingly applying the Industry 4.0 to the ‘Smart Services’ to develop advanced offerings such as the digitalized PSS [46]. Another example is the ‘smart connected products’ [6]. The application of digital technologies can bring environmental benefits by:

- simplifying mechanical components or replacing them by software. The physical product complexity is diminishing as well as the production steps needed to make and assemble them. For example, John Deere used to produce many versions of engines to provide customers different level of horsepower. It now can change the horsepower of a standard engine by using software alone [6].
- enhancing evergreen design that allows an upgrade of the physical products via software through remote control [6].
- developing remote services to supplement or replace traditional services performed on-site, regardless of the geographic dispersion of customers [46].
- reducing transport of physical goods [11,15]. For example, ICTs along with the development of 3D printing can offer PSS providers new opportunities of producing spare parts closer to end users [55].
- optimising service tasks and travel routes by applying apps¹.
- synchronising the supply chain of product and services
- establishing a shared network and database so that products can be easily searched, matched, shared, exchanged, rented, refurbished, remanufactured and recycled.

Leading industry players have shown that the smart digitalised services can bring multiple environmental benefits. For example, Schindler¹ uses the FieldLink app to provide service technicians with instant access to data on iPhone and iPad. They can identify the upcoming regulatory checks and predictive maintenance tasks, sort and combine tasks for service technicians and optimize the service routes based on their current location. The practice has decreased a driving distance of 40 million kilometers and prevented 4,435 tons of CO₂ emissions per year. Service technicians also use the Spare Parts app to search for the parts needed from the inventory of over 40,000 parts and order them just on the job site. Before that, technicians used estimations about which parts were needed, and then travelled back to office to order them. Schindler develops another FieldWiki app to give technicians

¹ <http://www.apple.com/business/schindler/>

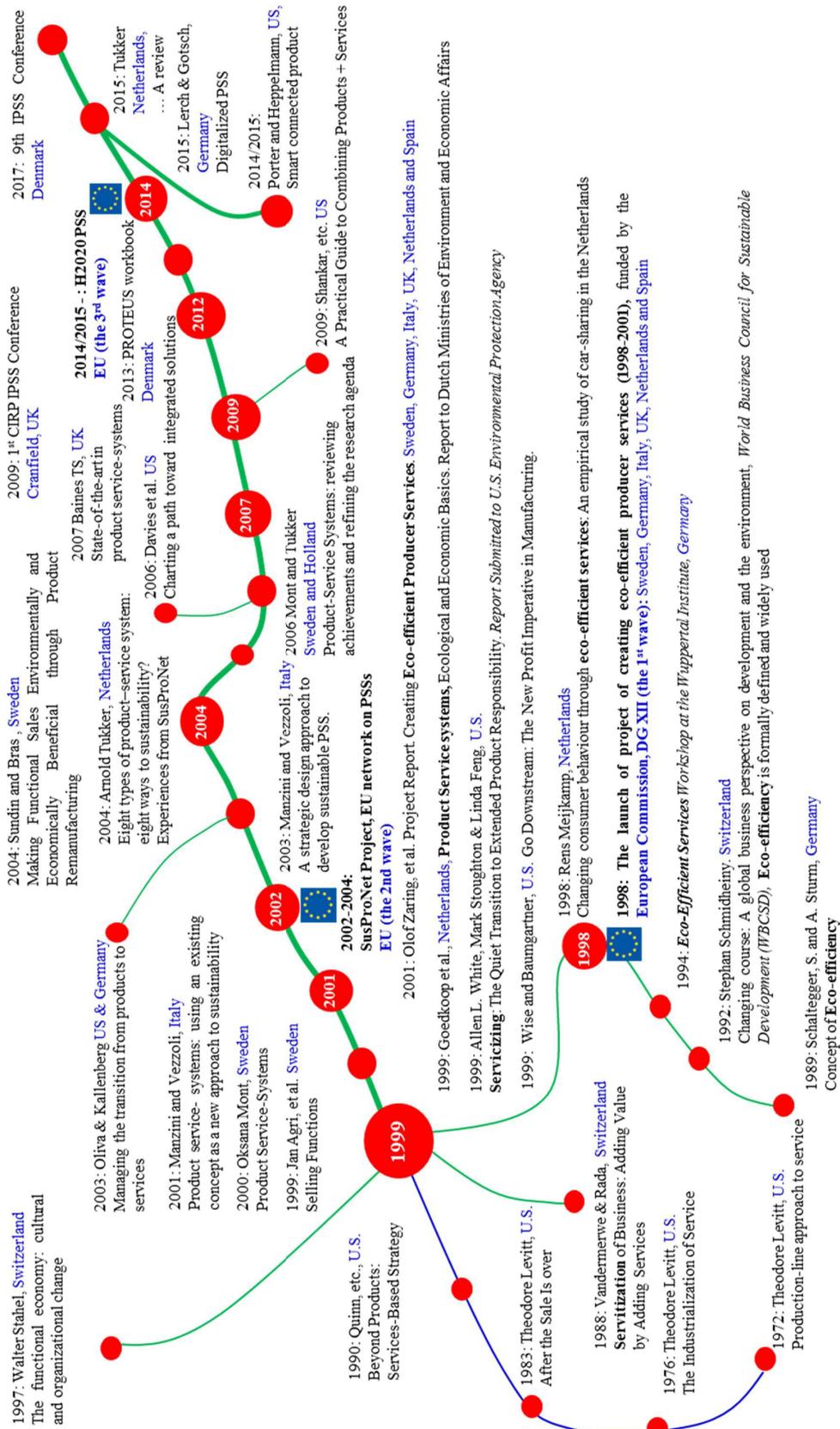


Fig. 1. The chronicle chart of PSS development

access to a digital library of latest multimedia documents including product specifications, service instructions, safety guidelines, and checklists, so that they can easily find the needed service information onsite instead of going back to offices. Further, it saves both paper and time spent on training. It is estimated that this saves as much paper as 17,760 meters tall every year.

For another example, ABB² develops the building control platform KNX, which uses its digital concept of Internet of Things, Services and People (IoTSP) to provide real-time energy consumption data and intelligent monitor and control services. This kind of application in one Microsoft building in Denmark can reduce energy usage by 30%.

3.4 Value co-creation

In the traditional market concept of product-oriented economy, value was created inside the firm and consumers were outside the firm. They had distinct roles of production and consumption [56]. However, socio-technical advancements make value creation a synchronic and interactive process [57]. Suppliers and customers are no longer on opposite sides, but interact with each other for new business opportunities [58]. For example, with the development of ICT, consumers are becoming more informed, connected, empowered, and active, and they desire the joint creation of value [56]. For another example, it is found that Remote Monitoring Technology (RMT) can enable the value co-creation process between the provider and customer, but the customer should be aware that some value propositions enabled by RMT cannot be delivered solely by a provider. It depends on their inputs and commitment to providing additional information [59]. Therefore, the capacity to manage information from all partners is crucial to the value co-creation process [60].

Further, value co-creation is not limited within PSS suppliers and customers and for economic aims alone. Elkington [31] pointed out that new types of economic, social, and environmental partnership are required to achieve sustainable value and outstanding triple bottom line performance. Aminoff et al., [61] argued that companies should develop collaborative networks of value co-creation to achieve a circular economy.

4 A framework of value co-creation in PSS

Based on the discussion above, a conceptual framework of value co-creation in PSS is constructed, as shown in Figure.2. The framework is developed from the Chinese Taiji philosophy that believes in the oneness before the duality and emphasizes the importance of maintaining balance between Yin and Yang, two opposite yet complementary forces forming the two primary aspects of universe. The framework embraces the main elements of PSS, including PSS providers and suppliers, PSS customers and end users, and the broad society in which it operates. At the core of the framework stands their interactive work 'value co-creation' that is connected and enabled by digital technology. For each of the

individual element, there is different focus. For example, PSS providers (integrators) together with suppliers focus on the system integration, synchronisation and convergence of their products and services. Meanwhile, PSS customers and end users add their inputs to receive the functional, emotional and social satisfaction by dialogue with PSS providers. All these activities will inevitably be linked to the surrounding society that promote joint efforts to achieve both economic growth and sustainability. Therefore, the framework can be used as an education model and guide for all PSS actors including suppliers, providers, customers, decision makers and the wide public who are seeking for value co-creation for sustainable development (e.g. the circular economy).



Fig. 2 The conceptual framework of value co-creation in PSS

5 Conclusion and next steps

The literature review leads to an innovative chronicle chart of PSS development that displays the correlations of the main terms. It also shows the evolvement of PSS from the original environmental focus to economic incentives. It indicates the need of co-creating value (and sustainability) among all PSS actors in the new economic pattern. The case studies show that digital technology can significantly facilitate the process of value co-creation and environmental sustainability. Value co-creation will become a main research theme of PSS in the forthcoming digital era. There are also some limitations in this paper. For example, a systematic literature review with a quantitative analysis would make the paper more rigor and robust. Second, it only uses second-hand data (rough it is validated by multiple sources) and therefore it needs further case studies to test and adjust the framework.

References

- [1] Stahel WR. The functional economy: Cultural and organizational change. In: Richards DJ, editor. *Ind. green game*, Washington: National Academy Press; 1997, p. 91 – 100.

² ABB innovations <http://www.abb.com>

- [2] The Ellen MacArthur Foundation. Towards the Circular Economy. 2013.
- [3] Pauli G, Corbis GS. The Blue economy. *UNEP Our Planet Mak Work* 2010;25:24 – 6.
- [4] Mathieu V. Service strategies within the manufacturing sector: benefits, costs and partnership. *Int J Serv Ind Manag* 2001;12:451 – 75.
- [5] Liu H, et al. Constructing a sustainable service business model: An SD logic-based integrated product service system (IPSS). *Int J Phys Distrib Logist Manag* 2014;44:80 – 97.
- [6] Porter M, Heppelmann JE. How Smart, Connected Products Are Transforming Companies. *Harv Bus Rev* 2015:97 – 114.
- [7] Oliva R, Kallenberg R. Managing the transition from products to services. *Int J Serv Ind Manag* 2003;14:160 – 72.
- [8] Martinez V, Bastl M, Kingston J, Evans S. Challenges in transforming manufacturing organisations into product - service providers. *J Manuf Technol Manag* 2010;21:449 – 69.
- [9] Sundin E, Bras B. Making functional sales environmentally and economically beneficial through product remanufacturing. *J Clean Prod* 2005;13:913 – 25.
- [10] Lindahl M, Sundin E, Sakao T. Environmental and economic benefits of Integrated Product Service Offerings quantified with real business cases. *J Clean Prod* 2014;64:288 – 96.
- [11] White AL, Stoughton M, Feng L. Servicing: The Quiet Transition to Extended Product Responsibility. 1999.
- [12] Zaring O, Bartolomeo M, Eder P, Hopkinson P, Groenewegen P, James P, et al. Creating eco-efficient producer services. Gotherburg: 2001.
- [13] Schrader U. Consumer Acceptance of Eco-efficient Services: A German Perspective. *Greener Manag Int* 1999:105 – 21.
- [14] Dobers P, Wolff R. Eco-efficiency and dematerialization: Scenarios for new industrial logics in recycling industries, automobile and household appliances. *Bus Strateg Environ* 1999;8:31 – 45.
- [15] Heiskanen E, Jalas M, Karna A. The dematerialization potential of services and IT. *Quest Futur Semin* 2000:1 – 41.
- [16] Agri J, Elisabeth Andersson, Alena Ashkin, John Soderstrom. Selling Functions CPM Report No.6. Gotherburg: 1999.
- [17] Vandermerwe S, Rada J. Servitization of Business: Adding Value by Adding Services. *Eur Manag J* 1988;6:314 – 24.
- [18] Baines, Lightfoot H. Servitization of the manufacturing firm: Exploring the operations practices and technologies that deliver advanced services. *Int J Oper Prod Manag* 2013;34:2 – 35.
- [19] Rothenberg S. Sustainability through servicing. *MIT Sloan Manag Rev* 2007;48:83.
- [20] Manzini E. Strategic design for sustainability: towards a new mix of products and services. *Proc. First Int. Symp.* 1999, p. 434 – 7.
- [21] Goedkoop MJ, Halen CJG van, Riele HRM te, Rommens PJM. Product Service systems, Ecological and Economic Basics. Netherlands: 1999.
- [22] Tukker A. Eight types of product - service system: eight ways to sustainability? *Bus Strateg Environ* 2004;260:246 – 60.
- [23] Mont OK. Clarifying the concept of product-service system. *J Clean Prod* 2002;10:237 – 45.
- [24] Davies A, Brady T, Hobday M. Charting a path toward integrated solutions. *MIT Sloan Manag Rev* 2006;43:39 – 48.
- [25] Shankar V, Berry LL, Dotzel T. A Practical Guide to Combining Products + Services. *Harvard Busiess Rev* 2009:95 – 9.
- [26] Ulaga W, Reinartz WJ. Hybrid Offerings: How Manufacturing Firms Combine Goods and Services Successfully. *J Mark* 2011;75:5 – 23. d
- [27] Park Y, Geum Y, Lee H. Toward integration of products and services: Taxonomy and typology. *J Eng Technol Manag* 2012;29:528 – 45.
- [28] Lerch C, Gotsch M. Digitalized Product-Service Systems in Manufacturing Firms. *Res Technol Manag* 2015;58:45 – 52.
- [29] Porter M, Kramer M. Creating Shared Value. *Harv Bus Rev* 2011;62 – 77.
- [30] Ulaga W, Eggert A. Relationship value and relationship quality. vol. 40. 2006.
- [31] Elkington J. Partnerships from Cannibals with Forks: The Triple Bottom Line of 21st-Century Business. *Environ Qual Manag* 1998;8:37 – 51.
- [32] Rocchi S. Enhancing sustainable innovation by design. Erasmus University Rotterdam, 2005.
- [33] Almquist E, Senior J, Bloch N. The Elements of Value. Measuring and Delivering what consumers really want. *Harv Bus Rev* 2016:46 – 53.
- [34] Porter M. Competitive Advantage: Creating and sustaining superior performance. vol. 15. 1985.
- [35] Normann R, Ramirez R. From Value Chain to Value Constellation. *Harvard Busiess Rev* 1993;July-Augus:65 – 77.
- [36] Allee V. Reconfiguring the Value Network. *J Bus Strategy* 2000;21:36 – 9.
- [37] Huppes G, Ishikawa M. Eco-efficiency and its terminology. *J Ind Ecol* 2005;9:43 – 6.
- [38] WBCSD. Creating More Value With Less Impact. 2000.
- [39] Lightfoot H, Baines T, Smart P. The servitization of manufacturing: A systematic literature review of interdependent trends. *Int J Oper Prod Manag* 2013;33:1408 – 34.
- [40] Smith L, Maull R, Ng I. Servitization and operations management: a service dominant-logic approach. *Int J Oper Prod Manag* 2014;34:242 – 69.
- [41] He T, Ho W, Zhang Y, Dey PK. Organising the business processes of a product servitised supply chain: a value perspective. *Prod Plan Control* 2016;27:378 – 93.
- [42] Mont O. Product-Service Systems. Swedish Environmental Protection Agency, Stockholm: 2000.
- [43] Sakao T, Sandström G, Matzen D. Framing research for service orientation of manufacturers through PSS approaches. *J Manuf Technol Manag* 2009;20:754 – 78.
- [44] Tukker A. Product services for a resource-efficient and circular economy - A review. *J Clean Prod* 2015;97:76 – 91.
- [45] Baines TS, et al. State-of-the-art in product service-systems. *Proc Inst Mech Eng Part B J Eng Manuf* 2007;221:1543 – 52.
- [46] Lerch C, Gotsch M. Digitalized Product-Service Systems in Manufacturing Firms. *Res Manag* 2015;Sep-Oct.:45 – 53.
- [47] Porter ME, Heppelmann JE. How Smart, Connected Products Are Transforming Competition. *Harv Bus Rev* 2014:65 – 88.
- [48] Mont O. Drivers and barriers for shifting towards more service-oriented businesses: Analysis of the PSS field and contributions from Sweden. *J Sustain Prod Des* 2002;2:89 – 103.
- [49] Vaitinen E. Eija Vaitinen Business Model Innovation in Product-Service System University of Technology, 2013.
- [50] Hanski J, Kunttu S, Rääkkönen M, Reunanen M. Development of knowledge-intensive product-service systems. *VTT Tech Res Cent* 2012.
- [51] Baines, Lightfoot HW, Benedettini O, Kay JM. The servitization of manufacturing: A review of literature and reflection on future challenges. *Int J Oper Prod Manag* 2009;20:547 – 67.
- [52] Manzini E, Vezzoli C. A strategic design approach to develop sustainable product service systems: *J Clean Prod* 2003;11:851 – 7.
- [53] Sundin E, Nässlander E, Lelah A. Sustainability Indicators for Small and Medium-sized Enterprises (SMEs) in the Transition to Provide Product-Service Systems (PSS). *Procedia CIRP*, vol. 30, 2015, p. 149 – 54.
- [54] Melville NP. Information systems innovation for Environment Sustainability. *MIS Q* 2010;34:1 – 21.
- [55] Holmström J, Partanen J. Digital manufacturing-driven transformations of service supply chains for complex products. *Supply Chain Manag An Int J* 2014;19:5.
- [56] Prahalad CK, Ramaswamy V. Co-creation experiences: The next practice in value creation. *J Interact Mark* 2004;18:5 – 14.
- [57] Ramirez R. Value co-production: Intellectual origins and implications for practice and research. *Strateg Manag J* 1999;20:49 – 65.
- [58] Galvagno M, Dalli D, Galvagno M. Theory of value co-creation: a systematic literature review. *Mark Serv Qual* 2014;24:643 – 83.
- [59] Grubic T, Peppard J. Servitized manufacturing firms competing through remote monitoring technology. *J Manuf Technol Manag* 2016;27:154 – 84.
- [60] Tokman M, Beitelspacher LS. Supply chain networks and service-dominant logic. *Int J Phys Distrib Logist Manag* 2011;41:717 – 26.
- [61] Aminoff A, Valkokari K, Kettunen O. Mapping multidimensional value(s) for co-creation networks in a circular economy. *IFIP Adv. Inf. Commun. Technol.*, vol. 480, 2016, p. 629 – 38.