Technical University of Denmark

Simulation-Based Business Case for PSS: A System Dynamics Framework

Rodrigues, Vinicius Picanco; Pigosso, Daniela Cristina Antelmi; McAloone, Tim C.

Published in:
Procedia C I R P

Link to article, DOI:
10.1016/j.procir.2017.03.014

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Rodrigues, V. P., Pigosso, D. C. A., & McAloone, T. C. (2017). Simulation-Based Business Case for PSS: A System Dynamics Framework. Procedia C I R P, 64, 283-288. DOI: 10.1016/j.procir.2017.03.014

Available online at www.sciencedirect.com
ScienceDirect
Procedia CIRP 64 (2017) 283 – 288
www.elsevier.com/locate/procedia

The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems

Simulation-based business case for PSS: a System Dynamics framework

Vinícius P. Rodrigues*, Daniela C.A. Pigosso, Tim C. McAloone

Technical University of Denmark (DTU), Produktionstorvet, Building 426, 2800, Kgs.Lyngby, Denmark

* Corresponding author. Tel.: +45 45 25 41 53; *e-mail address:* vipiro@dtu.dk

Abstract

Many potential business benefits have been widely associated with the implementation of PSS. Still, several significant challenges for transitioning to PSS persist, especially in regards to materializing the business benefits. To tackle such difficulty, this paper suggests a theory-driven concept of a business case for PSS implementation and management, based on a System Dynamics simulation framework. With a maturity-oriented theoretical perspective and the associated capability concepts, the study provides insights into how the development of PSS capabilities can potentially affect corporate performance over time. The paper's preliminary results identify the potential for managers and other decision-makers to use the business case simulator to assessing PSS-related business benefits and responding to multiple implementation scenarios and strategies.

Peer-review under responsibility of the scientific committee of the 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems.

Keywords: sustainability; system dynamics; simulation; business case; ecodesign maturity model

1. Introduction

An increasing number of corporations and researchers have been consolidating potential business benefits gained with the adoption and implementation of PSS [1–4]. Benefits range from business model innovation to the development of more environmentally-sound offerings [3,5]. However, many challenges still face companies in the implementation of PSS [1,6], specially in regards to seizing and measuring such PSS and other sustainability-driven benefits [7].

Within the domain of capturing and materializing corporate benefits, the concept of business cases arise as a collection of arguments that supports and documents the reasons why businesses should accept or pursue a certain cause [8,9]. With a maturity-oriented framework for PSS implementation and management (EcoM2) as the theoretical backbone [10], this study explores how capability building on PSS management practices can potentially influence corporate performance outcomes over time [11]. Having the dynamic and complex aspects as major components in integrating sustainability into business and product development [11], this paper proposes a first approximation for building a business case for PSS implementation through the use of a System Dynamics approach [12,13]. The SD simulation paradigm was selected over others (e.g. discrete event or agent-based) due to its suitability for application at higher, more aggregated and strategic levels and its lower dependency on hard data [14]. It is expected that the results of this paper contribute towards offering managers and decision-makers a theory-driven concept of a simulation-based framework to support the business case for PSS implementation.

2. The maturity-based PSS development

The Ecodesign Maturity Model (EcoM2) serves as the main theoretical framework for this paper. The EcoM2 was originally proposed in the literature as management framework for systematic integration of ecodesign into product development processes [10]. The model has been recently enhanced by the incorporation of best practices on the development of environmentally sustainable product/service-systems (PSS) [3,15] and social innovation [16]. The model encompasses three main elements: *practices, maturity levels and an application method*.

Peer-review under responsibility of the scientific committee of the 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems.
doi:10.1016/j.procir.2017.03.014

2.1. The EcoM2 practices

The EcoM2 practices are part of a comprehensive body of knowledge with more than 600 practices that are classified into *management* and *operational* practices. The management practices relate to the integration of sustainability issues into the strategic and tactical levels of the product development process. While management practices are generic and applicable to any company - irrespective of product specificities [10] – the operational practices are product-related and directly connected with technical characteristics of the product's design and life cycle. In the updated version of the EcoM2 model, the authors use the term *"best practices for PSS development"*. As a convention for this paper, we will refer to these practices as *PSS management practices* (PMP).

2.2. The maturity levels

The maturity levels consist of set of successive stages upon which sustainability-related issues are continuously embedded into the product development process. The maturity levels are based on the direct assessment of the management practices, which are then defined as a combination of the (i) evolution levels and (ii) the capability levels [3,10].

The model defines a capability scale that qualitatively measures how the company is applying a management practice. The 5-point scale is based on the Capability Maturity Model Integration (CMMI) [10] and can be described as follows [10]: **capability level 1** (*incomplete*) - at this level, the practice is not considered or is incompletely applied in the company; **capability level 2** (*ad hoc*) - the application of the practices is only targeted at accomplishing specific tasks or fixing particular problems; **capability level 3** (*formalized*) - a formalization is in place, with structured documents and processes, indicating the resources, infrastructure and responsibilities for the performance of the practice; **capability level 4** (*controlled*) - the practice has a controlled/monitored space, which means that its performance is constantly monitored through the use of key performance indicators; **capability level 5** (*improved*): at the highest capability level, the management practice has its performance continuously and systematically enhanced over time.

2.3. EcoM2 application method

The application method refers to a prescriptive approach based upon a continuous improvement fashion. The method supports companies in performing the implementation phase of capability-enhancing projects [3,10]. It is organized around two main phases. The first phase is composed of a diagnosis of the current maturity profile (as-is) and the deployment of roadmaps for improvement projects, based on the existing gap between the current and desired capabilities.

The second phase deals with the implementation of the improvement projects that are outlined in the roadmaps, along with strategies for change management and progress measurement. The business case bridges the gap in the transition from the first to the second phase. It assists in building the rationale for the deployment of roadmaps and their subsequent implementation. The business case framework makes use of the current and desired/future capabilities as inputs. The framework simulates the expected behavior of previously selected corporate performance outcomes over time, under a collection of assumptions and particular circumstances. In this sense, the framework should be fully customized to reflect the company's profile, with its main characteristics and parameters.

3. Methodology

The research methodology was based on a general System Dynamics approach, mainly focused on problem conceptualization, formulation of variables and relationships, model's test and evaluation, and - finally - policy and use analysis [6,17,18]. The particular method for deriving an exploratory simulation framework for a PSS business case was designed in two major phases: **(i)** literature and cross-content analysis and **(ii)** System Dynamics modelling and simulation.

3.1. Phase 1: literature and cross-content analysis

The first phase of the research method encompassed two main steps: literature analysis (Step 1.1) and cross-content analysis (Step 1.2). The literature analysis was fundamentally targeted at retrieving the EcoM2 management practices focused on PSS [3], the business benefits of PSS-related initiatives [8,9,19,20] and literature clues for describing initial assumptions for the variable's relationships in a business case model [6,17]. Due to the exploratory orientation of this paper, a group of the PSS management practices was selected.

The selection of practices is part of a fundamental orientation in quantitative modeling about preferring early and preliminary working versions of the model over greater levels of detail, which can be later added as necessary [18]. For the purpose of this paper, the market-oriented (or "externally-oriented") practices were chosen because their effect on corporate performance outcomes are easier to grasp at a first attempt of developing the business case framework.

The Step 1.2 involved a cross-content analysis of the selected PSS management practices against the reviewed business benefits [19,20], and against each other with a view to uncovering the potential cause-effect relations among the PSS management practices

3.2. Phase 2: System Dynamics modelling and simulation

The second phase of the research method also entailed two overall steps: qualitative modelling based on causal loop diagram (CLD) (Step 2.1) and quantitative modelling based on stock and flow diagrams (SFD) (Step 2.2).

The CLD conceptualizes the relationships among significant variables and pinpoint feedback structures, which steer the dynamics of a system [18,21]. The collection of PSS management practices defined in Phase 1 of the research method shaped the structure of the causal loops. Furthermore, the practices' relationships with the corporate performance outcomes - materialized as a result of the literature analysis (Step 1.1) and cross-content analysis (Step 1.2) – were also explored and outlined in the CLD. The guidelines recommendations for developing a CLD - proposed by Sterman [12] – were followed in this research, along with generic methodological procedures of Group Model Building [22]. The key variables and influencing factors of the problem were elicited based on the specialists' judgment and past experience in the area of PSS management and implementation.

The variables in a causal loop diagram are linked by arrows, which represent the causal relationships among them. Each of these causal arrows have a polarity (positive or negative). As a generic example, let's assume that variable A causes variable B (A → B). If the positive polarity (+) is assigned that *"if A increases, B will be always be higher than it would have been"*, while a negative relationship (-) amounts to the fact that *"if A increases, B will always be lower than it would have been"* [18]. The easiest way of identifying the polarities is to interpret the positive polarity as *"A and B move in the same direction"* and negative polarity as *"A and B move in the opposite direction"*. Mathematically, positive links are defined as partial differential equations $\partial A/_{\partial B} > 0$, whereas negative links follows the differential equation $\partial A/_{\partial B} < 0$ [18].

Subsequently, Step 2.2 translated the final CLD into a stock and flow diagram, which defines and displays the variables that accumulate over time (stocks) and the ones which operate as rates of change (flows) [18,23]. At this stage, it is also common to add new variables that are relevant for a better representation of the simulation and the system's structure [23,24]. For the exploratory purposes of this paper and due to limitations, a working simulation model was built for three practices in the collection of PMP selected for this study. The PMP were selected in regards to their fundamentally different scopes and types of generated outputs. Therefore, the profile of their influence on the performance outcomes is also different. Furthermore, the two practices were selected as a way to perform a more thorough examination of simulation model. With that, details and challenges could potentially be inspected further, before building a more complicated business case framework.

4. Results and discussion

4.1. Qualitative model: the causal loop diagram

Two fundamental feedback structures are related to the processes of capability building and erosion. The explicit consideration of the processes of capability building and capability erosion was grounded on consolidated System Dynamics applications in the fields of analysis and simulation of organizational capability dynamics [25,26]. The generic structure of these feedback loops are represented in **Figure 1.**

The positive feedback loops are self-reinforcing and, therefore, denoted with the letter **R**. Reversely, the negative loops are balancing (self-correcting) and, therefore, takes a letter **B**. All negative feedback loops have goals, which represents the desired state of the system [18]. In this particular CLD, all the goals are explicitly described as the practice's desired capability level (marked in green in Figure 1).

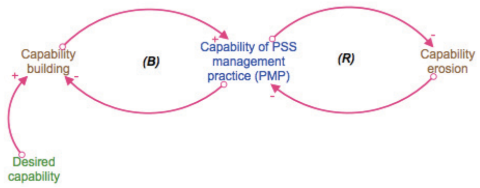

Figure 1: The fundamental and generic feedback structures for capability building and erosion.

The right-hand side positive (R) loop denoted by the loop containing the variables "capability level → capability erosion → capability level" is based on the idea that as capability *increases*, erosion *decreases*, if everything else is equal. So, the *higher* the erosion, the *lower* the capability will be, *ceteris paribus*. The two negative links form a self-reinforcing loop. Additionally, the left-hand side negative (B) loop defined by the loop containing the variables "capability level → capability building → capability level" signifies that the higher the capability, the lower capability building levels that will be required to reach the desired capability, while the higher the rates of capability building, the higher the capability level, if everything else is also held constant. The described mechanisms of capability building and erosion were based on fundamental concepts of the literature in capability dynamics [26] and heterogeneity of organizational performance [27,28].

The final CLD obtained through the performance of the described method is illustrated in **Figure 2**. The polarities are highlighted in the diagram. Since the fundamental feedback structure for capability building and erosion, described in Figure 1, repeats itself for every single practice of the diagram (blue variables), the variables of capability building and erosion were omitted to simplify the structure and improve the readability of the CLD. However, it is important to bear in mind that each of the variables representing the capability levels for the PMP displays the described feedback mechanisms with the two loops (one reinforcing for capability erosion and one balancing for capability building).

The following eight PMP [3,15] were selected to be part of the CLD: **1)** assess strengths and weaknesses of the current product portfolio and markets (PMP 1); **2)** identify available offerings in the market (PMP 2); **3)** understand customer value creation processes to develop suited and specific value propositions (PMP 3); **4)** identify the market value of the PSS compared to the competing product in terms of tangible and intangible value (PMP 4); **5)** identify customers' and stakeholders' requirements for the development of PSS (PMP 5); **6)** Define PSS offerings and value propositions to be provided to customers and stakeholders based on their needs (PMP 6); **7)** co-create value together with customers by developing service- and customer-oriented offerings (PMP 7) and **8)** increase the extent of interactions with customers through the PSS offerings (PMP 8). All the practices' capabilities are marked in blue in the CLD.

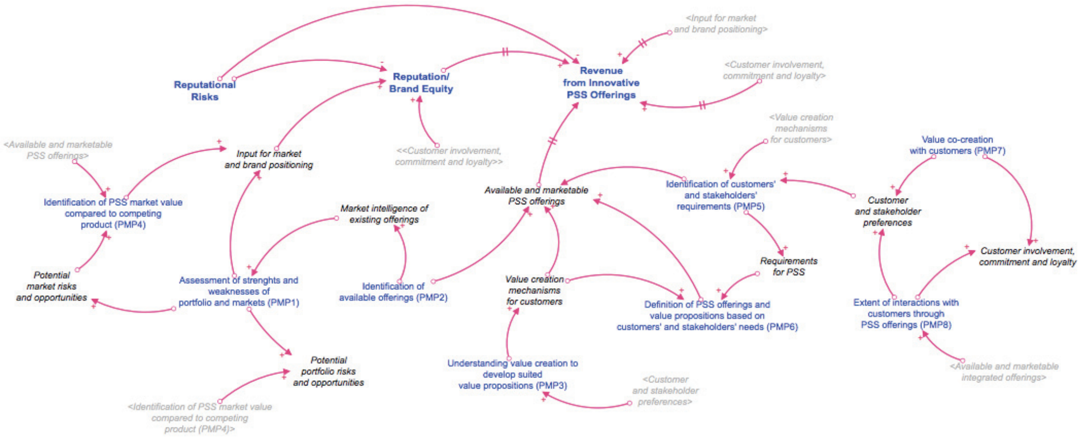

Figure 2: The final causal loop diagram (CLD) for the business case framework

The practices consist of activities that are performed across the entire PSS development process. In that sense, key outputs (results) are obtained from the application of the PMP, which are defined in the CLD as a mid-layer connecting the practices to the performance outcomes (benefits forming the business case rationale). The outputs are depicted in the CLD with a positive link from the practice's capability level and marked **black**. This relationship means that the higher the capability level, the higher the consistency/relevance of the output. Additionally, the performance outcomes (benefits) are in **bold blue**. The PMP are relatively independent, however one output might facilitate and directly influence the capability development of co-related practice.

Some of the outputs were selected and then, in turn, connected to three key performance outcomes (benefits), retrieved from the literature: **1)** risks of poor reputation [20,29], **2)** reputation and brand equity [29–31] and **3)** revenue from innovative PSS offerings (e.g. combinations of products and services) [19,20,32,33]. The outputs that are directly linked to the performance outcomes are replicated in the diagram with a **light grey** color, meaning they represent "ghost variables" (replications of existing variables). This occurs as a way to improve the readability of the model and avoid crossed arrows in the diagram. Note that the majority of the connecting arrows in the performance outcomes are marked with double parallel bars, which signifies the importance of delays in those relationships.

4.2. Quantitative model: the stock and flow diagram

Conceptually, the SFD displays the emergent behavior of a complex system. The fundamental representation of stocks is related to variables that can accumulate over time. On the other hand, flows are variables that can be represented as rates [6,18]. In this particular model, the capability levels are represented as stocks, with the capability building and capability erosion variables acting as flows (inflow and outflow, respectively). This formulation is also inspired in the literature of capability dynamics [25,26]. **Figure 3** shows the generic stock and flow structure of the business case simulation model.

The generic capability structure is initialized with the current capability and has its inflow (capability building) constructed upon a fundamental System Dynamics structure know as *"stock management structure"* [18]. It takes into account the adjustment for stock and the expected outflow, which is now represented by the variable capability erosion. Therefore, the capability structure is a goal-seeking one, with the desired capability level for the practice defined as the goal to be achieved. Subsequently, the capability erosion is formulated on the basis of a graphic function (or table function). In this formulation, capability erosion flow increases as the capability increases from 1 to 2, reaching the peak at capability level 2, and then decreasing as the capability moves away from level 2 towards capability level 5. The erosion mechanisms are substantiated in the fundamental concept of "organizational forgetting", which can be described as a theoretical combination of staff turnover and "insufficient organizational memory" [26].

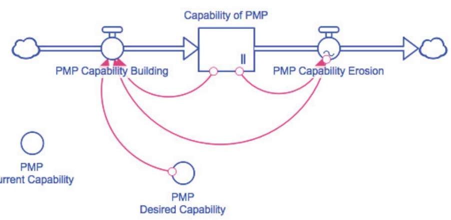

Figure 3: Generic stock-flow structure for the simulation mode

It is noteworthy that the selected PMP are directly contributing to two performance outcomes: reputation/brand equity and revenue from innovative PSS offerings, while no direct link has been identified between the practices' outputs and the outcome of reputational risks. Therefore, this outcome is treated as an exogenous variable, with random effect according to its intensity. The reputational risks influence the erosion of both reputation/brand equity and revenue from innovative PSS offerings. The consolidated SFD for this preliminary simulation model for the PSS business case presents the following practices: **PMP 3**, **PMP 5** and **PMP 7**.

The SFD is represented in **Figure 4**. The simulation model was defined to run for *48 months*. The EcoM2 implementation typically takes 24 months (two years) to be performed in regards to the capability increases defined in the roadmap. However, company might typically see changes in their performance outcomes within a 4-year planning horizon. The outcome of reputational risks was modeled as an exogenous variable, carrying random effects. This outcome is dependent on a complementary variable named "risk level", which varies from 1 to 3, and qualitatively sets the level of risk (e.g. from "low" to "medium" to "high"). Random effects were also contemplated for the reputation erosion the revenue erosion flows, due to their exogenous nature. Noticeably, the random formulation of this simulation model can be improved accordingly, as more accurate data comes in later versions of the business case. Model parameters were defined upon general points of reference in the literature [19], and translated into relative arbitrary scale/indexes (dimensionless/percentage). Such indexes represent potential relative contribution of PSS implementation to business performance outcomes.

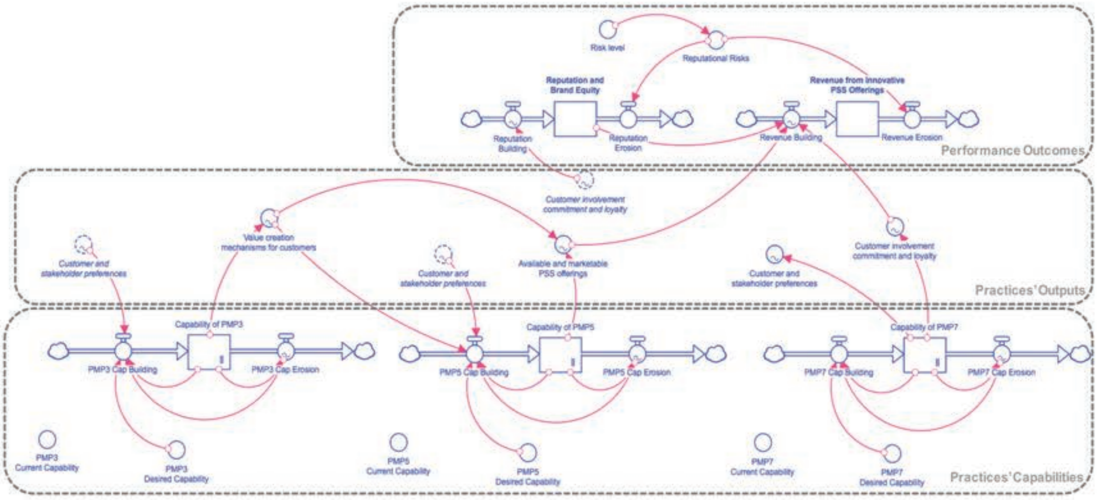

Figure 4: The layered stock and flow diagram (SFD) for the business case simulator, with 3 PSS management practices

A sensitivity analysis with 10 scenarios was performed for the simulation model. The parameters were, respectively, current and desired capability for PMP 3, PMP 5, PMP 7 and the risk level (low, medium, high). The graphs shown in **Figure 5** relate to each one of the 10 scenarios in the sensitivity analysis for reputation/brand equity and revenue from innovative PSS offerings. The labels in the graphs show the parameters in the abovementioned order.

Under the generic assumptions considered, both the reputation and the revenue are quite sensitive to the value for current capability, with higher and more persistent reputation/revenue for scenarios starting with higher capability. Furthermore, both outcomes display similar behavior (curves), however reputation tends to be more sensitive to capability increments, when compared to revenue.

Delays in gaining benefits from revenue are typically more pronounced than the ones for occurring for reputation. These benefits operate faster in than converted revenues, which can rely on longer cycles of commercialization of PSS offerings.

It is noteworthy that PMP 7 has the largest influence on reputation and revenue because one of its outputs ("customer and stakeholder preferences") supports the development of PMP 5 and the capability level of PMP 7 directly affects both performance outcomes. Furthermore, when the scenario representing the longest development of capability (from 1 to 5 for all practices) is subjected to a high level of risk (label "1,5,1,5,1,5, High"), the company sees no relevant increase in revenues, while reputation can grow some 10% after 4 years of strong capability development. On the other hand, performance is much stronger when the same capability development takes place under a low level of risk. This comparison suggests that developing PSS capabilities may be an important way to offsetting considerable levels of uncertainty and risk, which could confronted

5. Concluding remarks

The paper presented an initial approximation for a business case simulator for PSS implementation, which can be potentially used by decision makers to assess the test implementation scenarios and assess the performance outcomes. Due to its preliminary nature, limitations of the study can be pointed out: (i) the assumptions made and the incipient considerations constraint the utility of the results and applicability of the model; (ii) the high-level aggregation of some variables limit the capture of broader and important insights in the model; (iii) the lack of historical data makes it more difficult to parametrize the model.

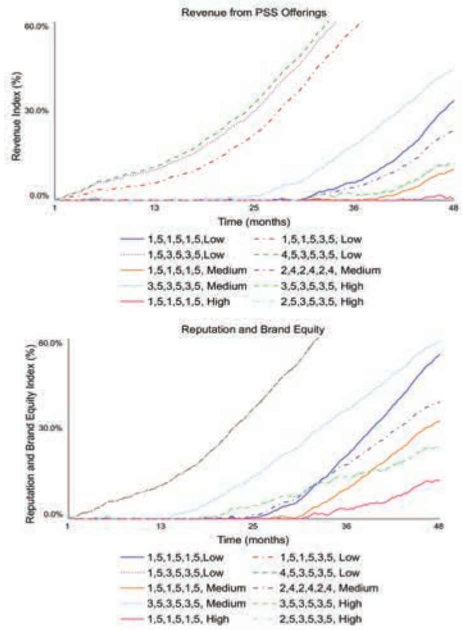

Figure 5: Curves of the 10 scenarios generated in the sensitivity analysis

Main contribution is geared towards the idea of laying out a foundational work to build future consolidated version of a practical business case simulation model. With that in mind, some strands for future development are: (i) increasing the reach of the model to cover all PMP; (ii) structuring the procedures of relationship building and data collection through qualitative methods; (iii) developing more robust indexes, parameters and patterns of behaviors as well as calibration methods for core variables; and (iv) instantiating the simulation model with real-world data. Moreover, the paper has the potential of opening future opportunities for more structured and sophisticated applications of the System Dynamics methodology in the PSS field, which has been predominantly dominated by qualitative research.

References

[1] F.H. Beuren, M.G. Gomes Ferreira, P.A. Cauchick Miguel, Product-service systems: A literature review on integrated products and services, J. Clean. Prod. 47 (2013) 222–231. doi:10.1016/j.jclepro.2012.12.028.

[2] M. Lindahl, E. Sundin, T. Sakao, Environmental and economic benefits of Integrated Product Service Offerings quantified with real business cases, J. Clean. Prod. 64 (2014) 288–296. doi:10.1016/j.jclepro.2013.07.047.

[3] D.C.A. Pigosso, T.C. McAloone, Maturity-based approach for the development of environmentally sustainable product/service-systems, CIRP J. Manuf. Sci. Technol. 15 (2016) 33–41. doi:10.1016/j.cirpj.2016.04.003.

[4] M.J. Goedkoop, C.J.G. Van Halen, H.R.M. Te Riele, P.J.M. Rommens, Product Service systems , Ecological and Economic Basics, 1999. doi:10.1111/j.1365-294X.2004.02125.x.

[5] S. Kim, C. Son, B. Yoon, Y. Park, Development of an Innovation Model Based on a Service-Oriented Product Service System (PSS), Sustainability. 7 (2015) 14427–14449. doi:10.3390/su71114427.

[6] S. Lee, Y. Geum, H. Lee, Y. Park, Dynamic and multidimensional measurement of product-service system (PSS) sustainability: A triple bottom line (TBL)-based system dynamics approach, J. Clean. Prod. 32 (2012) 173–182. doi:10.1016/j.jclepro.2012.03.032.

[7] V.P. Rodrigues, D.C.A. Pigosso, T.C. McAloone, Process-related key performance indicators for measuring sustainability performance of ecodesign implementation into product development, J. Clean. Prod. 139 (2016) 416–428. doi:10.1016/j.jclepro.2016.08.046.

[8] S. Schaltegger, F. Lüdeke-Freund, The "Business Case for Sustainability" Concept: A Short Introduction, Lüneburg, 2012. http://ssrn.com/abstract=2094238.

[9] A.B. Carroll, K.M. Shabana, The Business Case for Corporate Social Responsibility: A Review of Concepts, Research and Practice, Int. J. Manag. Rev. 12 (2010) 85–105. doi:10.1111/j.1468-2370.2009.00275.x.

[10] D.C.A. Pigosso, H. Rozenfeld, T.C. McAloone, Ecodesign maturity model: A management framework to support ecodesign implementation into manufacturing companies, J. Clean. Prod. 59 (2013) 160–173. doi:10.1016/j.jclepro.2013.06.040.

[11] V.P. Rodrigues, S.N. Morioka, D.C.A. Pigosso, M.M. de Carvalho, T.C. McAloone, Exploring the dynamic and complex integration of sustainability performance measurement into product development, in: Int. Des. Conf. - Des. 2016, Dubrovinik, Croatia, 2016: pp. 433–442.

[12] J.D. Sterman, Business Dynamics : Systems Thinking and Modeling for a Complex World, Irwin/McGraw-Hill. Boston, Mass. (2000) 928.

[13] J.W. Forrester, Industrial dynamics, 1961.

[14] S. Brailsford, Theoretical comparison of discrete-event simulation and system dynamics, Discret. Simul. Syst. Dyn. Manag. Decis. Mak. (2014) 105–124. doi:10.1002/9781118762745.ch06.

[15] D.C.A. Pigosso, T.C. McAloone, Supporting the development of environmentally sustainable PSS by means of the ecodesign maturity model, Procedia CIRP. 30 (2015) 173–178. doi:10.1016/j.procir.2015.02.091.

[16] D.C.A. Pigosso, T.C. McAloone, Best practices for the integration of social sustainability into product development and related processes, Sustain. Innov. 2015. (2015) 1–4.

[17] L.F. Luna-Reyes, D.L. Andersen, Collecting and analyzing qualitative data for system dynamics: methods and models, Syst. Dyn. Rev. 19 (2003) 271–296. doi:10.1002/sdr.280.

[18] J.D. Sterman, Business Dynamics: Systems Thinking and Modeling for a Complex World, 2000. doi:10.1057/palgrave.jors.2601336.

[19] IRRC Institute, Driving Revenue Growth Through Sustainable Products and Services, New York, 2015.

[20] B. Willard, The NEXT Sustainability Wave: Building Boardroom Buy-In, New Society Publishers, Gabriola Island, BC, Canada, 2005.

[21] S. Lee, W. Han, Y. Park, Measuring the functional dynamics of product-service system: A system dynamics approach, Comput. Ind. Eng. 80 (2015) 159–170. doi:10.1016/j.cie.2014.12.005.

[22] J.A.M. Vennix, Group Model Building: facilitating team learning using system dynamics, John Wiley, 1996.

[23] Y.-W. Liao, Y.-M. Wang, Y.-S. Wang, Y.-M. Tu, Understanding the dynamics between organizational IT investment strategy and market performance: A system dynamics approach, Comput. Ind. 71 (2015) 46–57. doi:http://dx.doi.org/10.1016/j.compind.2015.02.006.

[24] Y. Geum, S. Lee, Y. Park, Combining technology roadmap and system dynamics simulation to support scenario-planning: A case of car-sharing service, Comput. Ind. Eng. 71 (2014) 37–49. doi:10.1016/j.cie.2014.02.007.

[25] N.P. Repenning, J.D. Sterman, Nobody ever gets credit for fixing problems that never happened: Creating and sustaining process improvement, Calif. Manage. Rev. 43 (2001) 64–88. doi:10.1109/EMR.2002.1167285.

[26] H. Rahmandad, N.P. Repenning, Capability Erosion Dynamics, Strateg. Manag. J. 37 (2016) 649–672. doi:10.1002/smj.

[27] I. Dierickx, K. Cool, B. De Constance, Asset Stock Accumulation and Sustainability of Competitive Advantage, Manage. Sci. 35 (1989) 1504–1511. doi:10.1287/mnsc.35.12.1504.

[28] H. Rahmandad, J. Sterman, Heterogeneity and Network Structure in the Dynamics of Diffusion: Comparing Agent-Based and Differential Equation Models, Manage. Sci. 54 (2008) 998–1014. doi:10.1287/mnsc.1070.0787.

[29] S.P. Saeidi, S. Sofian, P. Saeidi, S.P. Saeidi, S.A. Saaeidi, How does corporate social responsibility contribute to firm financial performance? The mediating role of competitive advantage, reputation, and customer satisfaction, J. Bus. Res. 68 (2015) 341–350. doi:10.1016/j.jbusres.2014.06.024.

[30] J. Park, H. Lee, C. Kim, Corporate social responsibilities, consumer trust and corporate reputation: South Korean consumers' perspectives, J. Bus. Res. 67 (2014) 295–302. doi:10.1016/j.jbusres.2013.05.016.

[31] C. Maden, E. Arıkan, E.E. Telci, D. Kantur, Linking Corporate Social Responsibility to Corporate Reputation: A Study on Understanding Behavioral Consequences, Procedia - Soc. Behav. Sci. 58 (2012) 655–664. doi:10.1016/j.sbspro.2012.09.1043.

[32] B. Clemens, Economic incentives and small firms: Does it pay to be green?, J. Bus. Res. 59 (2006) 492–500. doi:10.1016/j.jbusres.2005.08.006.

[33] S. Schaltegger, F.L. Freund, E.G. Hansen, Business cases for sustainability: the role of business model innovation for corporate sustainability, Int. J. Innov. Sustain. Dev. 6 (2012) 95. doi:10.1504/IJISD.2012.046944.