Introducing strategic decision support systems for sustainable product-service innovation across value chains

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Abstract

Most companies do not have a coherent and systematic approach for incorporating sustainability criteria into their decision support systems. Given this, what would such a *strategic* decision support system (SDSS) look like that that is coherent throughout a development process and systematically incorporates (1) a full sustainability perspective, including (2) a broader approach to meeting needs by product-service systems, and (3) interfaces toward both specific groups of decision makers and specialized in-depth tools? We anticipate such an SDSS being structured by a framework for strategic sustainable development that provides a principle-based definition of sustainability and a systematic method to identify problems and solutions by backcasting from that definition. This should aid identification of potential benefits and challenges of shifting from a product-only focus to a focus on product-service systems. Additionally, the new sustainability and product-service system decision support should be flexible enough to be incorporated into existing decision-making processes. It will likely be formed around a built-in product development process at the companies.

Introduction

Product developers have traditionally focused on a relatively narrow set of technical and business economic aspects, but the sustainability problems in today's society provide good reason to widen the perspective (Charter and Chick, 1997, Ritzén, 2000, Hallstedt, 2008). Current impacts of raw material extraction, production, distribution, use and disposal show that new practices are needed. A product's impacts - positive and negative throughout its life-cycle - are largely determined by decisions during early development phases (Roozenburg and Eekels, 1995, Charter and Chick, 1997, Ritzén, 2000, Hallstedt, 2008).

The increasingly competitive global economy makes it harder for companies to maintain market share solely by offering high quality physical products. To remain competitive, companies often find it necessary to provide more services with their products. It is often not so much the physical artefacts that consumers necessarily demand, but the *services (functions)* they provide (Alonso-Rasgado et al., 2004, Ericson and Larsson, 2005). Furthermore, many products are increasingly containing electronics and software. This integration not only increases the complexity of the initial product development, but also increases the need for services to support them. It is often not possible for a single company to generate such a total offer. Even though business developers and managers may have frequent contacts with customers and suppliers it is yet almost unheard of that companies are able to create direct working relationships between product developers from companies along value-chains (Larsson et al., 2008). A mindset focused on product functions thus drives towards extended value-chain cooperation among companies – the "*extended" or "virtual" enterprise (VIVACE-Project, 2007)*.

Today there are many overarching methods and tangible specialized tools intended to take sustainability issues, value chains and life-cycle perspectives into account during product and business development. This includes life cycle assessment (LCA), casual loop diagramming (CLD), investment calculus, computer aided design (CAD), and design for product-service systems (PSS)—sometimes called functional product development (FPD) (Ericson and Larsson, 2005). Many of these tools are possible because and strengthened by an increasing sophistication of computer-based decision support systems (DSS) (Alter, 1980, Power, 2004).

Our approach to sustainable product innovation (SPI) is based upon a framework for strategic sustainable development (FSSD) that incorporates backcasting from sustainability principles. The FSSD has been developed and continues to be elaborated in international collaboration with researchers and practitioners (Broman et al., 2000, Holmberg and Robèrt, 2000, Robèrt, 2000, Robèrt et al., 2002). In Robèrt et al. (2002), pioneers of several tools for sustainable development concluded that this framework is well suited for structuring other tools, clarifying overlaps and gaps, and for coordinating an optimal use of each tool.

To help practitioners work at both strategic and operational levels, we have created *bridging tools*. These are created by scrutinizing different tools against the FSSD to find synergies and gaps. Examples of tools include templates for sustainable product development (TSPD) (Ny et al., 2008) and strategic life cycle management (SLCM) (Ny et al., 2006). Bridging tools can be used as part of a process referred to as a method for sustainable product development (MSPD), which combines the sustainability thinking provided by the FSSD with a concurrent engineering development model (Byggeth et al., 2007, Hallstedt, 2008).

All these bridging tools tools (and others) are helpful when making individual decisions during the product development process. However, tools will be of even greater help if they can be structured in an SDSS such as the “design space” concept suggested by Ny and colleagues (2006).

Objectives

In this paper we present an idea for a *strategic* decision support system (SDSS) that should systematically:

1. Incorporate a full sustainability perspective to respond to increasingly-important market demands and opportunities,
2. Provide opportunities to optimize value chains by enabling a life-cycle overview of the entire value chain,
3. Support transitioning of traditional product solutions into product-service systems focused on meeting (market and basic human) needs, and
4. Connect operational and strategic levels in companies.

Suggesting an SDSS

Theoretical Foundation

<u>Sustainability through FSSD Integration</u>

To incorporate sustainability, we suggest the SDSS being structured by a framework for strategic sustainable development that provides a principle-based definition of sustainability and a systematic method to identify problems and solutions by backcasting from that definition. In practice, based upon the MSPD, this integration can be done through guiding questions that product/business developers need to answer at different stages in the PSS innovation process. Obtaining an answer may require, among other things, different types of modeling and simulation, including causal loop diagrams linking the PSS with socio-ecological implications.

<u>Value Chain Optimization through PSS Focus</u>

Further, the SDSS will provide opportunities to identify potential benefits and challenges of shifting from a product-centric focus to a focus on product-service systems. In practice, this is also done by questions that are presented to product/business developers, who may answer those questions by utilizing modeling and simulation support tools.

<u>Connecting Strategic and Operational Company Levels</u>

Additionally, the SDSS interfaces are expected to be flexible in design and implementation so that they can be incorporated into business and product developers’ existing decision-making processes. They will likely be formed around an optional built-in product development process and include interfaces toward increasingly specific in-depth tools within areas like life cycle modeling, technical simulation and investment calculus.

Referring to figure 1, *multiple user interfaces* will be designed around a an SDSS or “portal” to provide access to the tools necessary to support a specific type of user. A product developer focused on detailed technical aspects of a physical product will access tools that are different than tools accessed by a business manager making decisions regarding the business model around the PSS. *Product-Service questions* will guide the design of the physical products and services intended to meet customer needs. *Business development questions* will guide the development of the business model around the PSS. An *SDSS manual* will communicate both how to use the portal and also the theory that underlies the portal. An *experience database* will collect and provide access to users' experiences so that, where appropriate, knowledge can be shared across companies, value chains and even industries. *Specialized tools* aid users in considering specific details of certain aspects throughout the innovation process, often requiring significant time or other resources. *Bridging tools* aid a user in knowing when and how to apply specialized tools, as well as if it is possible to narrow the specific application of the specialized tool in order to both conserve resources and ensure that simulation results are framed within a sustainability context. An example of a bridging tool is SLCM, which focuses LCA efforts into areas of primary concern from a full strategic sustainability perspective (Ny et al. 2006). *Experts on specialized tools* are also made available to aid portal users. A *theoretical foundation* is created by bringing together sustainable product innovation, product-service system innovation and a framework for strategic sustainable development.

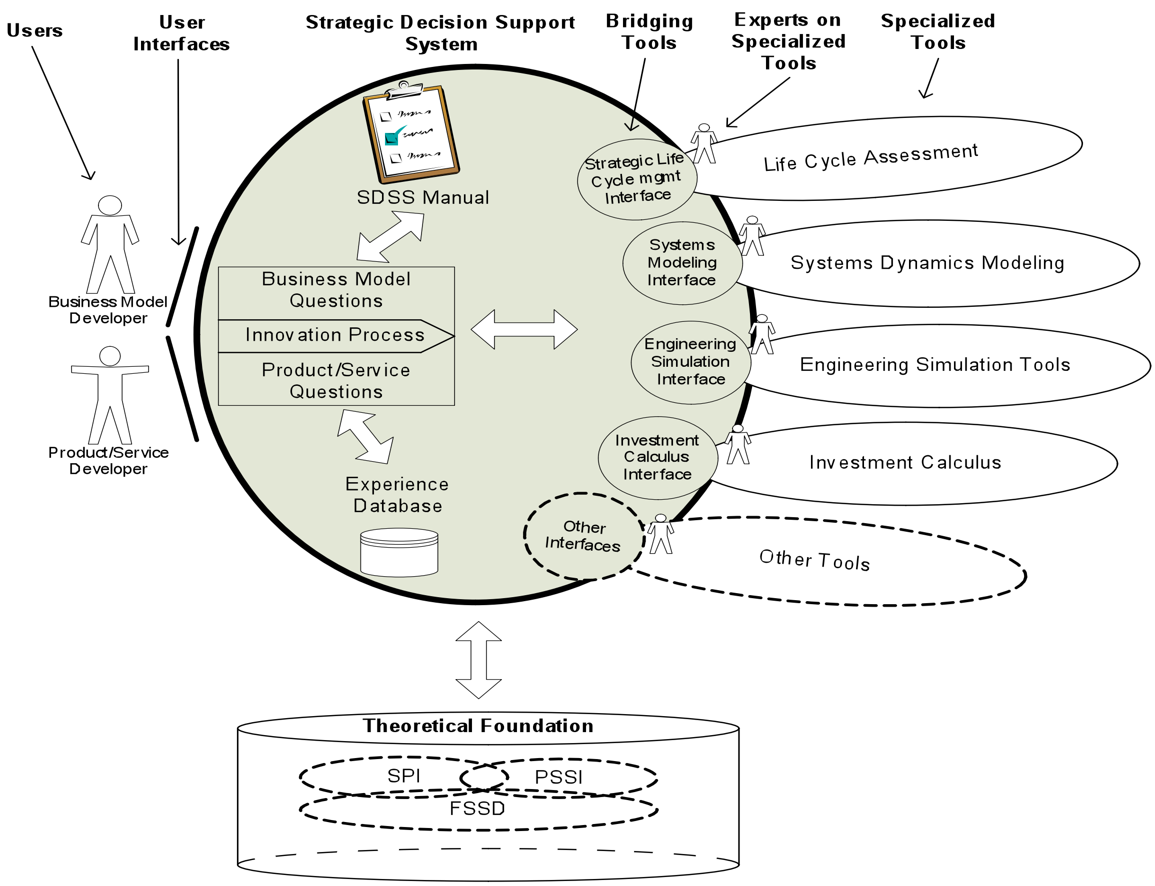

Figure 1. *How a Strategic Decision Support System (SDSS) could link Business and Product-Service Developers with suitable tools and experts throughout innovation processes by building systematically upon a theoretical foundation.*

Practical Use

Business/product developers access the SDSS through their workstations. Depending upon the stage of innovation, different guiding questions will be presented. When the choice of materials is relevant, guiding questions will help to choose materials that are less likely to be problematic from a sustainability standpoint. To answer this question, support tools (e.g. LCA) may be helpful, though require substantial amounts of time. Bridging tools can help to guide the user to which specific aspects or applications of the support tools that can be used to aid in making decisions. Direct links to experts on both the bridging and the specialized tools are also included (e.g. a product developer could contact an expert in SLCM and/or LCA). As guiding questions are answered, those answers can be saved for future reference so that sometimes lengthy investigations need not be repeated.

A user will have access to both a public and a company-specific component. The public component will interact with a network of users from other companies and it will offer several services, such as:

1. Guidelines on how to use the tools and services available through the public component.
2. Reports on strengths and challenges of certain established methods and tools and hands-on guidelines for how they can be helpful when the FSSD is used to support sustainable product innovation.
3. Generic questions that guide users in considering sustainability aspects throughout the innovation process.
4. Newly developed methods and tools that are integrated "bridges" between the FSSD and the established methods and tools, helping users to start from the sustainability overview that the FSSD provides before, if needed, going into more detailed studies.
5. Links to a network of experts and institutions that may give further support and background information on each method and tool.
6. A "global" experience library or database which collects experiences from all companies and experts on experiences from using the methods and tools of the SDSS.

The company-specific component is expected to contain local applications of the SDSS solution, including:

1. Guidelines on using the company-specific aspects of the SDSS.
2. Guiding questions that support users in considering sustainability aspects throughout the innovation process that are customized for the company.
3. Company-specific tools that are contextualized by the SDSS.
4. A library containing experiences shared only within the company.

Discussion

Challenges

Intellectual property rights and traditional business models provide barriers for optimization across a value-chain. This means that the reluctance to share detailed product information with other companies may hinder total value-chain optimization. This could be dealt with through, among other things, new methods to support a clearer distinction between what information that can be shared and what needs to remain confidential.

In addition to knowing what content to share, there is a technical challenge of sharing that information across multiple computer systems among many actors in a value chain. The field of knowledge enabled engineering aims to deal with such issues (Bylund et al., 2004) and therefore could be helpful in the development of SDSS.

The intent is to make the SDSS general enough to be broadly applicable to industry at large but still adaptable to specific company needs. Such needs include interfacing with local technology systems, e.g., computer aided design/computer aided manufacturing, accounting and customer relationship management systems. We intend to work with several case studies in order to be exposed to multiple working environments and thereby gaining experience from which to derive generic approaches for the SDSS that could be applied in any company. We have experience from using this approach when developing the generic MSPD (Byggeth et al., 2007). In this case the FSSD was incorporated in a generic concurrent engineering development model and tested in several companies.

Opportunities

We believe effective application of SDSS could significantly aid in optimizing value chains by supporting decision-makers in taking a full value-chain perspective throughout the innovation process, (e.g. through waste reduction, selection of materials with less end-of-life consequences or expenses, etc.).

In addition, the whole-system perspective gained through using the SDSS could enable decision-makers to early on identify potential market changes due to sustainability-related issues (e.g. increasing water demand, increasing oil prices, climate change legislation, etc.) with the benefits of anticipating/avoiding costs, gaining market share, or major investments that are not suitable for the long term. Moreover, specialized tools are often time and/or resource intensive, so the suggested bridging tools are focused on providing guidance on where and how the specialized tools can provide the most benefit.

Furthermore, the SDSS concept inherently connects the strategic and operational levels within a company by offering tailor-made interfaces that are based upon the same foundational concepts to both business developers/managers and traditional product developers.

Further work

We expect implementation of the SDSS concept to start with an overview study of existing tools and methods for sustainability integration (steps 1 and 2 in figure 2) and onsite case studies with product developers and business-related decision-makers in companies (steps 3-5). The case studies will include identifying the gap between the company's current DSS and an envisioned SDSS and then identify ways to close that gap. From these specific experiences we will draw generic guidelines for how other companies could implement an SDSS (step 6 in Figure 2).

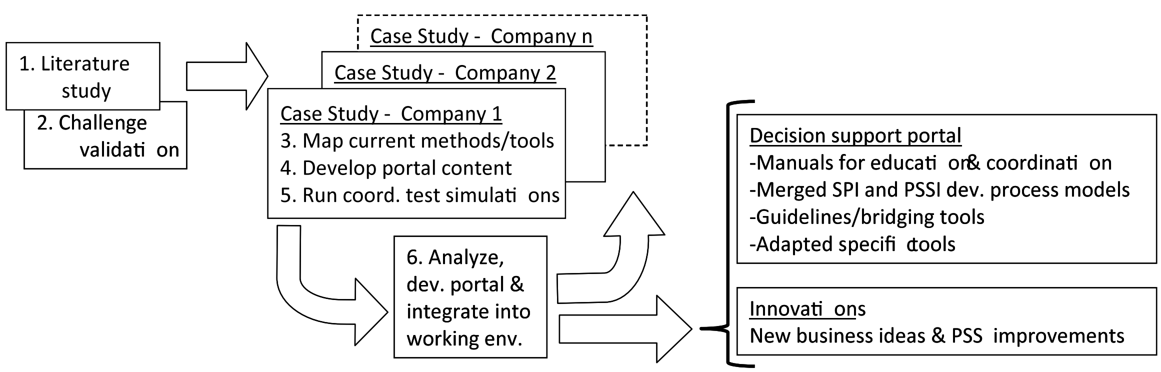

Figure 2: *Iterative research approach & expected results*

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