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Achieving sustainable new product development by integrating product life-cycle management capabilities

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ABSTRACT

Concerns about sustainability matters have been growing significantly during the last decades. The triple bottom line approach – an often applied operationalization of sustainability integrating the economic, social, and ecologic aspects of sustainable development – has gained attention in companies, especially with regard to sustainable products. Nevertheless, the integration of sustainability in new product development is still in an early stage. Hence, the purpose of this paper is to elaborate on the impact of the three product life-cycle management pillars, i.e. product data management, process management, and engineering project management, on facilitating the integration of new product development and sustainability. An explorative multi-case study with a total of 23 interviews in six automotive companies has been conducted. The case studies show that sustainability requirements increase complexity in new product development, in which globally-dispersed design teams, product variation, and time-to-market pressure already have to be managed. In order to mitigate these challenges in new product development, the incorporation of the three product life-cycle management pillars may be beneficial. By doing so, globally-dispersed processes become streamlined across departments and companies, development accuracy due to a joint database is enhanced, and the utilization of cross-company capabilities focusing on sustainable product development is established. This research provides practical implications and argues for integrating product life-cycle management into sustainable new product development.

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1. Introduction

Product complexity and globally dispersed product design activities challenge today's companies in high technology industries (Grieves, 2006). These challenges impact whole product life-cycles – at least in theory (Masclé and Zhao, 2008). Thus, companies are forced to invest in concepts like product life-cycle management (PLM) supporting their operations management in reducing managerial complexity in new product development (Stark, 2005). PLM expresses the engineering point of view of the product life-cycle concept and integrates the aspects of people, processes, and data (Stark, 2005). For example, the lack of a well-defined PLM process is seen as a key factor in companies missing targets in new product introduction and therefore causing delayed market entry, as was the case of the Airbus A380 (TechDrummer, 2008). Similarly, Toyota's massive vehicle recalls were caused due to the cars' complexity and might have been avoided by implementing a thorough PLM concept (Gu, 2010).

Sustainability activities demanded by customers, non-governmental organizations, and legislation are increasing the complexity of product design (Bevilacqua et al., 2007; Hu and Bidanda, 2009). Influencing a product's sustainability characteristics is prevalent in the design phase (Evans et al., 2007). This can also be seen in the case of Airbus trying to reduce weight for economic and environmental reasons. Less weight of a plane enables designing bigger planes with more capacities and less environmental-impacting exhausts. Although research on green new product development (Polonsky and Ottman, 1998; Baumann et al., 2002; Lee and Kim, 2011) has emerged, it is not sufficient as social aspects also require attention as reflected in growing research activities and requests for sustainable approaches in supply chain management (Seuring and Müller, 2008), operations (Kleindorfer et al., 2005), engineering (Allenby and Allen, 2007), and sourcing (Pagell et al., 2010), as well as the request for sustainable products (Bevilacqua et al., 2007). Consequently, green new product development (NPD) needs to move to the next step toward a sustainable new product development. Sustainable development is grounded in the Brundtland Commission's definition as “a development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 42). This definition is the first in which a sustainable development had been expressed and noted. Henceforth, it can be considered as the root for all concepts and

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recent research in the today's vast field of sustainability. The Brundtland Commission focused on two key points. On the one hand the 'needs' of generations are addressed, which are mainly concentrating on the desires of poor people of the world. On the other hand the thought of timeliness was of interest. Future generations should not be impacted negatively by current developments. This means that it is not sustainable to fulfill the needs of the current generation when impairing the situation of future generations. This includes especially the exploitation of natural resources which are hard or not at all to replenish. Processes or activities that use resources now without providing them to future generations are not in line with a sustainable development. The Brundtland Commission also stated that a sustainable development has to be initiated today in order to give future generations a realistic chance to fulfill their needs. Nevertheless, it is also mentioned that these actions require governmental support to guide companies on a sustainable development path. Sustainable development needs to be done on a regional, national, and global level. The rather vague definition (Callens and Tyteca, 1999) of sustainable development by the Brundtland Commission (WCED, 1987) is difficult to infer for companies and has been specified by the triple bottom line approach into integrating economic, social, and ecologic aspects (Elkington, 1997; Dyllick and Hockerts, 2002). The link of the triple bottom line to new product development must be achieved in order to design and produce sustainable products. From an engineering point of view, products pass through a life cycle with different characteristics of processes and data and involve many people and companies. Henceforth, product life-cycle management, i.e. product data management, process management, and engineering project management, becomes the focal point when dealing with NPD.

Combining the challenges of sustainability, NPD, and the advantages of PLM leads to the research question addressed: how do the product life-cycle management pillars support a successful sustainable new product development? This paper seeks to answer this question by drawing on insights from six case studies in the automotive industry. The automotive industry is known for complex products and processes (Thun and Hoenig, 2011) as well as for strong sustainability requirements (Orsato and Wells, 2007). In addition, the automotive industry is seen as a pioneer in product life-cycle management activities (Grieves, 2006), allowing valuable and reliable insights to be expected.

The remainder of the paper is structured as follows. Section 2 introduces the literature on NPD, sustainability, and PLM. It provides a table connecting new product development success factors with the PLM pillars and sustainable activities. In Section 3, the case study methodology is described and justified. Section 4 presents the findings from the cases, while Section 5 gives the discussion. The conclusion and further research opportunities are drawn in Section 6.

2. From terminology to a basic conceptualization

In order to address the research question the theoretical background provides the basic comprehension of the three concepts: sustainability management, new product development and the

product life-cycle management pillars. This is represented in the following four sections. The fifth section explains the integrative approach of all concepts.

2.1. Sustainability management

Research within the area of sustainability attracts a large community in academic literature (e.g. Huang and Rust, 2010; Schneider and Meins, 2012; Caniato et al., 2012; Lee and Farzipoor Saen, 2012). The concept of the triple bottom line is mainly in used in connection with companies (Wiedmann et al., 2009). The definition of the triple bottom line integrates economic profitability, environmental protection, and social responsibility (Elkington, 1997; Dyllick and Hockerts, 2002; Kleindorfer et al., 2005). The comprehension of each triple bottom line aspect is shown in Table 1 and is followed in this study. The triple bottom line is seen as an adequate guidance for organizations specifying the Brundtland Commission's definition of sustainable development (Naslund and Williamson, 2010).

The Brundtland Commission defined sustainable development as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The advantage of the triple bottom line lies in a supply chain wide focus. The development of sustainable products aims at fulfilling the users' needs with the purpose of reducing environmental and social impacts of products while providing economic value to the company during the whole product's life cycle (Hsueh, 2011). Accordingly, companies are able to gain competitive advantages through sustainability (Campbell, 2007). The competitive advantage can also affect the whole supply chain because corporate sustainability does not solely impact the company but also the whole supply chain (Vachon and Mao, 2008; Seuring, 2011; Caniato et al., 2012). Shrivastava (1995, p. 955) provides a further definition of sustainability with a strong environmental focus, referring to "the potential for reducing long-term risks associated with resource depletion, fluctuations in energy costs, product liabilities, and pollution and waste management". However, the interpretation does not include aspects of a social performance. The often-mentioned statement that the social dimension of sustainability has been neglected becomes evident here (Aguilera et al., 2007; Mu et al., 2011).

2.2. New product development

Research in new product development (NPD) has been of interest for several decades (e.g. Leonard-Barton, 1992; Muffato, 1998; Kleinschmidt et al., 2007; Afonso et al., 2008), attracting researchers in engineering services (e.g. Perrone et al., 2010), collaboration aspects (e.g. Ramesh and Tiwana, 1999), and global teams (e.g. Rauniar and Rawski, 2012). New product development focuses on the transformation of a market opportunity into a product available for sale with short development cycles (Krishnan and Ulrich, 2001; Atuahene-Gima and Murray, 2007). Short development cycles enable companies to react quickly to changed market demands (Hu and Bidanda, 2009). Following a market opportunity is a vital aspect to remain competitive. Today this

Table 1

The triple bottom line (based on Elkington (1997), Dyllick and Hockerts (2002) and Kleindorfer et al. (2005)).

Triple bottom line	Description
Social	Skills, motivation, and loyalty of employees and business partners Value is added to the community which a company operates in
Environmental	Reduction of the consumption of natural resources below the natural reproduction
Economic	Guaranteed cash-flow at any time while producing return to shareholders

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