CHALLENGES AND PRECONDITIONS TO BUILD CAPABILITIES FOR SUSTAINABLE PRODUCT DESIGN

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Abstract

Sustainable product innovation has previously been found to be positively correlated to competitiveness. However, in order to build capabilities for sustainability integration one must first understand companies' current state. The overall aim is therefore to identify common preconditions and challenges for sustainability integration in product innovation. A questionnaire study, targeting employees with roles in product development, was conducted at four medium-sized to large product development and manufacturing companies in Sweden. Results show that capabilities for sustainability integration are perceived as decisive for future company success, but are not considered to be correspondingly high prioritized today. Decision making is focused on material selection and energy efficiency, so no full socio-ecological sustainability perspective is covered. Formal decision support tools are only used by half of respondents and are a main area for improvement. Identified challenges include short-term economic thinking, lack of sustainability criteria and vague management commitment. Based on these findings, seven recommendations for companies are presented and validated.

Keywords: Sustainability, Case study, Ecodesign, Sustainable product development, Capability

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1 INTRODUCTION

There are numerous challenges for companies to reach socio-ecological improvements of new innovations for products, services or production methods in parallel to reaching economic targets (Urbaniec, 2014). Such challenges include, e.g., how to identify which the most relevant sustainability aspects to consider are, to what degree a concept performs in relation to an ideal sustainable solution, how profitability and sustainable values can be estimated for a longer time perspective, and how sustainability criteria can be related to other parameters and requirements. Some of these challenges have been explored in several research projects together with case companies with the purpose to give guidance for sustainable product development. Sustainable product development means here that a strategic sustainability perspective is integrated and implemented into the early phases of the product innovation process, including life-cycle thinking. For example, in Hallstedt (2015) an approach for identifying the most important socio-ecological sustainability criteria together with tactical design guidelines and a qualitative sustainability compliance index tool were suggested and tested in a manufacturing company. Another case studied how sustainability assessment could give guidance in creating scenarios with net present value results in comparison between two manufacturing processes. In this way a long-time perspective was included and the sustainability parameters were related to a monetary value (Hallstedt et al., 2015). Despite these findings, it remains unclear how companies can build capabilities for sustainability integration and implementation, considering all three dimensions of sustainability for a company, i.e., environmental, social and economic dimensions (Elkington, 1997). A review of literature reveals that there is little knowledge on why and how companies integrate environmental sustainability into new product development (Dangelico and Pujari, 2010).

The purpose of this study was therefore to identify some common challenges and preconditions, with the aim to learn more about the driving forces of companies and some potentials to build capabilities for sustainability integration and implementation in product development. Another contribution of this study is the use of this knowledge as a baseline for proposing a novel set of recommendations for companies that can support further integration and implemention of a full socio-ecological sustainability perspective into product development.

1.1 Background

The early stages of the product development process play a key role, as most of a product's social and ecological impacts during its life cycle are determined by decisions taken during early phases (McAloone and Tan, 2005). Several studies found that technological eco-innovation, as well as green product and process innovation, are positively correlated to competitive advantage (Chen et al., 2006; Küçükoğlu and Pınar, 2015; Ryszko, 2016). Reasons for this can be improved corporate image, more motivated employees or increased profitability (Neville et al., 2006). External requirements, such as tougher legislation, customer requests, and material constraints, can also function as driving forces for company initiatives (Spangenberg et al., 2010; Testa and Iraldo, 2010). Hallstedt et al. (2013) identified key elements for successful implementation of a strategic sustainability perspective in product development. Support tools and methods on the operational level, routines and practices on the tactical level and commitment and shared understanding of the strategic maturity level (Baumgartner and Ebner, 2010) are building blocks for durable capability for sustainable product development. Still, a better understanding of the preconditions regarding capabilities for sustainable product innovation is needed to get better knowledge of why and how companies want to integrate sustainability in product development.

1.2 Outline

In the following section 2, the research approach is presented, which is followed by section 3 containing the results and discussion from the survey. In section 4, based on the findings, seven recommendations for companies are suggested that constitute key steps on the way towards a further increasinging of capabilities for sustainability integration. Finally, section 5 concludes by proposing necessary measures and changes as well as a suggested focus in research to enhance eco-innovations and more sustainable solutions in the future.

2 METHOD

A web-questionnaire was designed, guided by the work of Blessing and Chakrabarti (2009) and Karlsson (2009), with the aim to be generic and relevant for any product development and manufacturing company. The questions were distributed via an online questionnaire using Google Forms. The focus of the survey was to identify common preconditions and capabilities for sustainability integration in product development. Here, preconditions include attitudes and prioritization of sustainability, as well as driving forces. Questions regarding capabilities focused on which and how method and support systems are used in product development, and which and how sustainability related decisions are taken during the innovation process. A short introduction to the background and purpose of the study, how sustainable development at the company relates to product development, as well as an explanation of the terms 'sustainability' and 'formal decision support' were included. In total, 22 questions were presented that addressed (i) general information about the respondent such as role and working experience, (ii) the importance and prioritization of sustainability integration as well as motivations for doing this, (iii) decision making, (iv) decision support, (v) challenges, and finally, (vi) improvement suggestions. Different types of open and closed questions were combined in order to gather both quantitative and qualitative data and to achieve synergistic effects (Eisenhardt, 1989) and a balance between the weaknesses of each type of questions and scaling techniques (Karlsson et al., 2009). Pilot testing was done prior to the study at one company, which led to improvements of questions through increased clarity and to more effective distribution and data collection.

The questionnaire study was performed at four multinational case companies, all doing product development and manufacturing, between the fall of 2015 and the spring of 2016. Similar to Høgevold et al. (2014) and Dangelico and Pujari (2010), purposeful sampling was applied and the companies were selected because they have started to work more actively with sustainability aspects beyond the level of mere compliance, without being companies that define themselves solely from a sustainability perspective. This makes them relevant for understanding how companies work with sustainability in product development, while, at the same time, they are representative for a broad spectrum of businesses, which allows for a more valid generalization of the results. Company A is a medium-sized (about 100 employees) lamp manufacturer with their competitive edge being smart lighting solutions with environmental-friendly long-life lamps. Company B is a large (about 2000 employees) manufacturer of jet engine components in the aerospace industry. Company C is a large (about 4000 employees) machine manufacturer. Company D is a research center with about 250 employees for a multinational company in the manufacturing industry. The studied company sites were located in Sweden.

The recipients of the questionnaire were selected in a non-probabilistic way, in consultation with the companies: first, a list of roles that are actively involved in the product development process was compiled, based on literature and previous experience in the field. Second, the list of roles was discussed with contact persons at the companies in order to make adjustments to fit the list to the individual cases, and to identify suitable recipients. The goal was to include as many suitable people in the study as possible, to get representative results and to avoid selection bias. That means that all employees who had one of the listed roles and were identified as involved in product development were included as recipients. This design resulted in a large number of recipients and was chosen to ensure that the recipients' roles were related to the product innovation process and that the selected target group was proper for the topic of the questionnaire. This means that the target group consisted of those with roles in product development and technology development such as product developers, project managers, engineers, purchasers, environmental and sustainability engineers and managers. The recipients had two to three weeks to fill out the questionnaire. Multiple e-mail reminders were sent out during that time period to achieve a high response rate.

The results were aggregated and analysed in Microsoft Excel. Within-case analysis was performed prior to the searching for cross-case patterns. In this way, the necessary depth of understanding and familiarity with each case as a stand-alone entity was aquired, before comparing results from different cases (Eisenhardt, 1989). Several open questions were included in the questionnaire with the aim to gather the respondents' thoughts and attitudes (Blessing and Chakrabarti, 2009). Because of the mainly explorative nature of this study, conventional content analysis (Hsieh and Shannon, 2005) was deployed in order to avoid preconceived categories in the coding process (Kondracki et al., 2002). Instead, categories were derived inductively (Mayring, 2000), directly from the data. First, all answers were read repeatedly in order to gain a sense for the whole. Second, key words that capture central thoughts or attitudes were

identified to form categories. Each answer was then assigned to one or multiple categories. Two researchers were involved in the analysis and interpretation of the qualitative answers to the open questions to ensure that they were interpreted correctly and to avoid misunderstandings, following guidance by Eisenhardt (1989). Results are presented as percentages of answers that were assigned to the different categories. A literature review was conducted to validate and compare the findings with previous research and theory.

3 RESULTS AND DISCUSSION

3.1 Respondent characteristics

Most respondents were engineers or managers, but people in other roles, such as project leaders, purchasers, and respondents in marketing, also answered the questionnaire. Response rates were generally high and in total 306 responses were analysed, Table 1. The respondents' working experience at the companies was quite balanced; both relatively new employees and employees who have been working at the companies for 25 years or more formed part of the respondents.

Table 1. Main characteristics of the case companies and the questionnaire.

Company	Turnover, k€	Employees	Recipients	Respondents	Response rate*
A	75 000	100	22	16	73%
B	800 000	2000	183	69	38%
C	2 750 000	4000	82	38	46%
D	50 000	250	236	183	78%

* Overall response rate. Note that response rates for some questions, mainly the open ones, were lower in some cases, which is further described in corresponding sections.

3.2 Sustainability importance, prioritization and driving forces

At all companies, the respondents think that an increased capability to integrate sustainability aspects is very important for the future of the company (mean 7.6 – 9.4; scale 1 not important - 10 very important), Figure 1.

"I think that it is of key importance for the future of [Company D] and for future generations to put as much as possible focus on these topics." - Senior Scientist at Company D
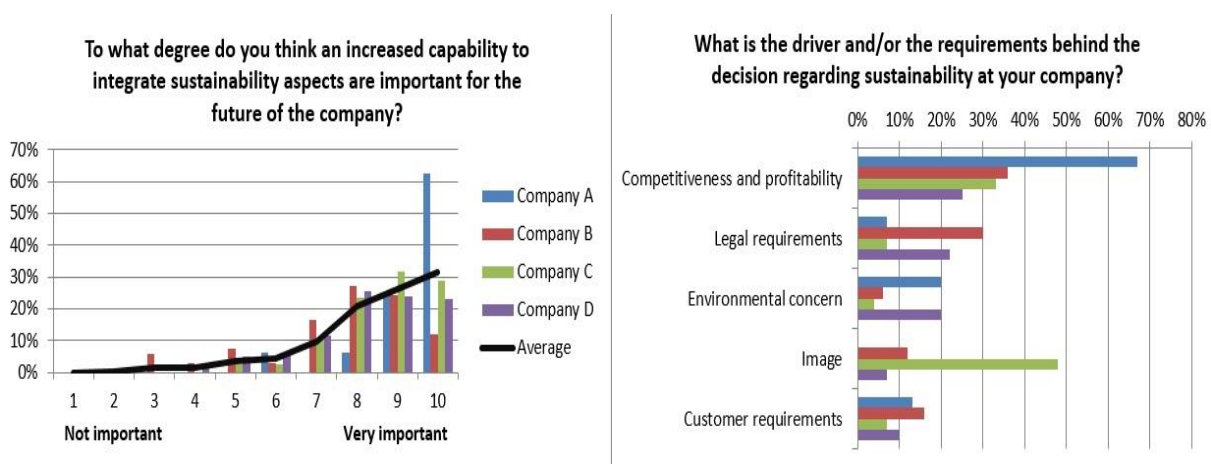
Figure 1. The perceived importance of increased capabilities for sustainability integration and the drivers behind sustainability related decisions.

The main driving forces and reasons for why it is perceived as important are:

- Competitiveness in the long run: To include sustainability aspects is perceived as good business and a necessity for long-term competitiveness and survival. Furthermore, respondents state that it would lead to cost reduction and a lower total cost of ownership of their products, making them more attractive for customers.

- Increased importance in society in general: Sustainability is increasingly focused on in all parts of society and awareness is rising. As a result, stricter legal requirements, e.g., are expected.
- Environmental concern: It is perceived as important because it is the right thing to do, for our common future on this planet.
- At Company C, image and reputation is perceived as the most dominant driving force while it is not among the top three mentioned aspects at any of the other companies.

Only at one company, respondents perceive that it is a strategic decision that acts as a strong driving force in today's decision making. However, when asked for how high the respondents perceive that sustainability is prioritized today on the strategic and operational levels, the means are considerably lower, between 5.8 - 7.7 and 5.8 – 6.5 respectively (scale 1-10). This discrepancy shows that the importance of sustainability integration is recognized but that there is a challenge of translating these future requirements into correspondingly high prioritization and actions in the present. At two of the companies, there is also a gap between the perceived prioritization of sustainability on the strategic and operational levels, which might indicate that strategic ambitions are not always followed up by practical action, or, in other words, 'walking the talk' is still a challenge.

The results show clearly that it is competitiveness reasons that drive sustainability work at the companies. Environmental concern and ethical reasons, while still mentioned, are not the main drivers behind sustainability decisions. The results strengthen the findings by Høgevold et al. (2014, 2015) that indicate that there has been an evolutionary shift in driving forces over time: from ecological to economic, from cost-orientated to value-orientated economic effects, and from within-organizational to beyond-organizational social boundaries. However, Høgevold et al. (2014, 2015) studied companies that had started their sustainability efforts 10-20 years ago. Therefore, it remains unclear whether companies that start their efforts today also follow the evolutionary process from ecological to economic driving forces, or if companies today acknowledge and are driven by a business rationale from the beginning. The role of reputation is likely dependent on the type of company and its position in the value chain. This means, for a company that is further down on the value chain, closer to the end-user, that reputation and brand are likely more important driving forces than for companies further up in the value chain.

3.3 Decision support

There is little difference between the respondents' opinions on how good existing decision supports are: across all companies, average values range between 5.0 and 5.9 (scale 1-10), which means that they are considered to be neither very bad nor very good. At the same time, the most common improvement potential suggested at the companies was better decision support.

At all case companies, 40% of respondents either state that they are not aware of any formal decision support tools or did not answer this particular question. This number rises to about 50% for the question on which formal decision support tools they actually use. The most well-known tools are in most cases life-cycle assessment (LCA), material restriction lists, risk assessment and environmental impact assessment. The overall most used tools are risk assessment, ISO 14001, and checklists for material restriction and health safety and environment (HSE). This finding is also confirmed in Zetterlund et al. (2016). Dangelico and Pujari (2010) found in a similar study that companies start to embrace a life-cycle perspective and that LCA was considered as a useful tool and was getting rather common. Our results do also show that a life-cycle perspective is considered in many cases but do not support the findings concerning LCA as a useful and common tool. On the contrary, while being well known, LCA is very rarely used in the daily work at the case companies. The opinions regarding to what degree existing decision support includes social sustainability aspects are vague. First and foremost, it is noticeable that there is confusion regarding what social sustainability actually means and how to identify social issues.

3.4 Challenges and problems

Between 40 – 60% of the respondents at each company identified some challenges related to sustainability integration and implementation in product development, Figure 2. The common pattern is that *costs and short-term economic thinking are perceived as the dominant barrier* when making decisions regarding sustainability. Frequently stated reasons by the respondents are that: (i) the relation between sustainability and profitability is not obvious; (ii) product cost might get higher and it is unclear if all customers are willing to pay extra for a more sustainable product, and in the short term there might be; (iii) higher investment costs; and (iv) a perceived risk of decreased profitability. This means that

product development and the final products are not allowed to cost more in order to become more sustainable. These results seemingly reveal a paradox as, at the same time, an increased capability to integrate sustainability aspects is considered to be very important by almost all respondents and the main reason and driver for this is that it is a necessity for long-term profitability and survival. This paradox is also visible in the results of Høgevold's et al. (2014) interview study, in which interviewees highlight the economic benefits of sustainability proactivity through decreased costs and risks and improved sales margins, while at the same time pointing out the challenges of being sustainable and profitable at the same time. Based on the answers of the questionnaire, there are two explanations: (i) Sustainability is not seen as a completely integrated part yet. It is still, at least by some respondents, seen as an additional goal needing investements of time and resources in order to be achieved. This means that there still is a perceived conflict between sustainability goals and economic goals. Instead, as described by Willard (2005), sustainability, when properly worked with, can function not only as a goal in itself but even as a means to achieve other goals, including economic ones, which implies that sustainability and profitability may exist in a symbiosis. (ii) The time perspective might be the critical point. Even if it is a matter of long-term survival and profitability, a strong sustainability profile might cause some costs and risks in the short run. In addition, today's incentives are strongly focused on short-term economic performance. Therefore, one of the most urgent questions is how long-term and short-term profitability can be balanced.
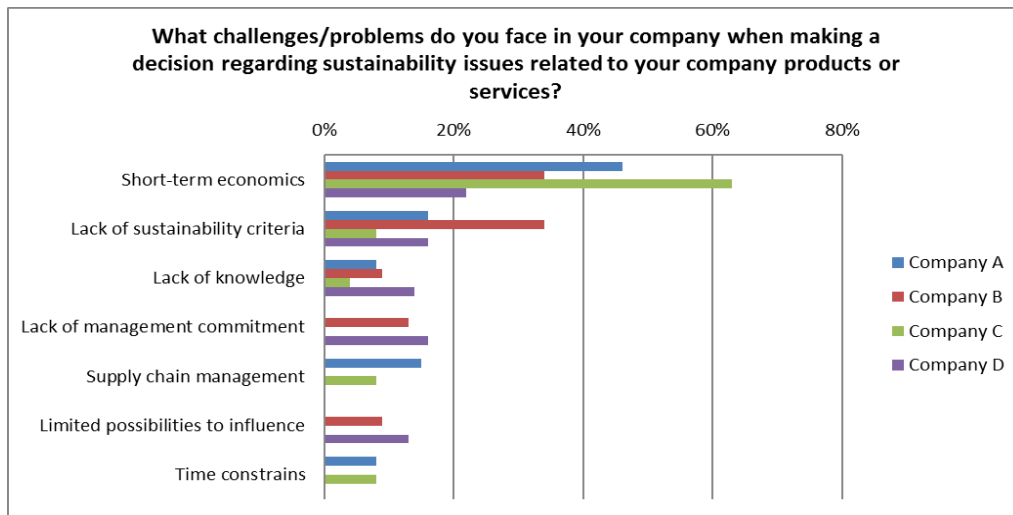

Figure 2. Perceived challenges for decision-making regarding sustainability.

Another frequently stated challenge is the *lack of sustainability criteria*. Today, there is no attractive approach that can be used to identify and decide on the most sustainable solution. Further, there is currently no formalized way to handle trade-offs, for example between technical requirements and sustainability performance or between different kinds of sustainability effects. As sustainability often is hard to quantify and measure, there is a difficulty to translate such aspects into specific requirements that product developers can work with. Some respondents also perceive that there is a *lack of management commitment* as sustainability issues are not seen as highly prioritized. To have *control over sustainability aspects throughout the whole supply chain* is considered challenging, especially for complex products with an extensive supplier network. Moreover, at some of the companies, respondents perceive that they have *limited possibilities to influence*, as they simply "are not really in the position of deciding on sustainability aspects" (specialist at Company D), for example because those decisions are taken at the business unit. Finally, *lack of knowledge can be a barrier*. This concerns, on the one hand, the concept and term 'sustainability' of which there is no common understanding at the case companies. On the other hand, many products are very complex, which makes it difficult to assess their sustainability impact.

3.5 Improvement potential

Between 40 and 60% of respondents wrote improvement suggestions, Figure 3. The most mentioned suggestion is better or other support tools. According to the respondents, these different tools should be able to give a comprehensive overview of the environmental impact of different design alternatives and

of how trade-offs can be dealt with. They should also incorporate a full sustainability perspective. Currently, material selection and energy efficiency are the dominating sustainability aspects that are considered, as also found by Poulikidou et al. (2014) and Dangelico and Pujari (2010), while many other aspects are neglected. At the same time, the respondents ask for tools to be formalized, easy to use and not require too many resources and time. Suggestions are checklists, guidelines, databases, criteria for sustainability and a way to calculate and compare sustainability impact and costs. Consolidation of existing tools, methods and approaches to enhance a selection from companies, is one of nine expected development areas for sustainable design (Pigosso et al., 2015).
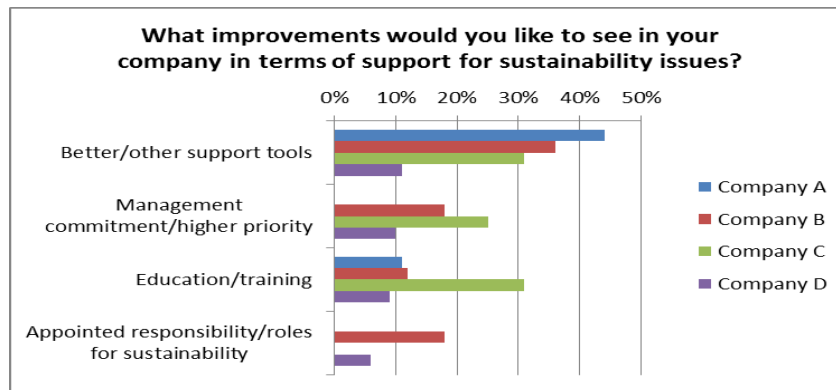

Figure 3. The most mestioned sustainability-related improvement suggestions.

Up to 25% of the respondents suggest that higher top management commitment that is visible and well communicated is needed. That also includes proactivity in the area, as well as defined directives and goals for sustainability that clarify how employees are allowed and expected to prioritize sustainability in their work. For example, one respondent asks for a "*clear guideline on how much effort one should put [into] pursuing sustainability aspects in a project*". As several studies have pointed out, having senior management commitment with a well-communicated sustainability plan is a key element for successful sustainability integration (Hallstedt et al., 2013; Schendel and Birkhofer, 2007).

Several respondents stress that "sustainability issues need to permeate the whole organization" (product developer at Company D) and all activities and parts of the company instead of being a separate, additional workload. Willard (2005) has pointed out that this might well be one of the greatest challenges in a company's work with sustainability issues, but that it is also the one factor that results in the greatest benefits, both for the company and for society's sustainability challenge. So far, there are still some respondents who see sustainability issues as just one more thing that has to be taken care of, an additional goal and one more checklist to work through. This means that the case companies still have work to do in order to make sustainability a truly integrated part of their business and to reach the 'integrated strategy' stage on Willard's sustainability compliance ladder. As a support in this maturity progression some respondents would like to see more clearly appointed roles for sustainability implementation, including specialists that can help the rest of the organization.

More training is needed, for example in the form of lectures, workshops or good examples from other companies or projects, in order to increase awareness and knowledge on sustainability issues, including what sustainability means. As, e.g., the question on social sustainability aspects in decision making revealed, there is currently no shared and holistic understanding of the concept of 'sustainability'. This however, is an important pre-requirement for all sustainability-related future work as well as effective communication. A framework has been developed to achieve shared understanding of the concept of 'sustainability', i.e., the Framework for Strategic Sustainable Development, which includes basic sustainability principles (Broman and Robèrt, 2015). The social dimension in this framework has recently been developed and concretized in the work by Missimer (2015).

3.6 Sustainability training makes a difference

Respondents at Company D, who have participated in sustainability training, scored significantly higher on how important they think that sustainability integration capability is for the future of the company (p=0.02). This group also knows and uses more formal decision support tools as compared to respondents who have not participated in the training (p<0.01). Even though these results are based on

data from only one company, they provide an interesting empirical indication of the positive effect of sustainaibility training on employees' attitudes and practical behaviour regarding sustainability, as previously suggested by Bansal and Roth (2000). The respondents' request for more education and training on sustainability issues might therefore well be a meaningful and effective improvement possibility.

4 SEVEN IMPROVEMENT RECOMMENDATIONS FOR COMPANIES

The results of this research provide a novel set of company preconditions that form the necessary starting point for further attempts to catalyse the integration of a full socio-ecological sustainability perspective in product development. Based on the findings, Figure 4 shows seven key steps for companies that could work as focus areas for further increasing capabilities for sustainability integration in product innovation. They have no sequential order and can advantegeously be worked with in parallel. The recommendations were presented to the four companies in the survey and the response showed that these are perceived as legitimate and helpful by bringing up and concretizing which issues to focus on. Thereby the recommendations could be used as a support in creating a roadmap towards sustainability implementation in the product innovation process. Their actual applicability and usefulness will be further tested in future research.
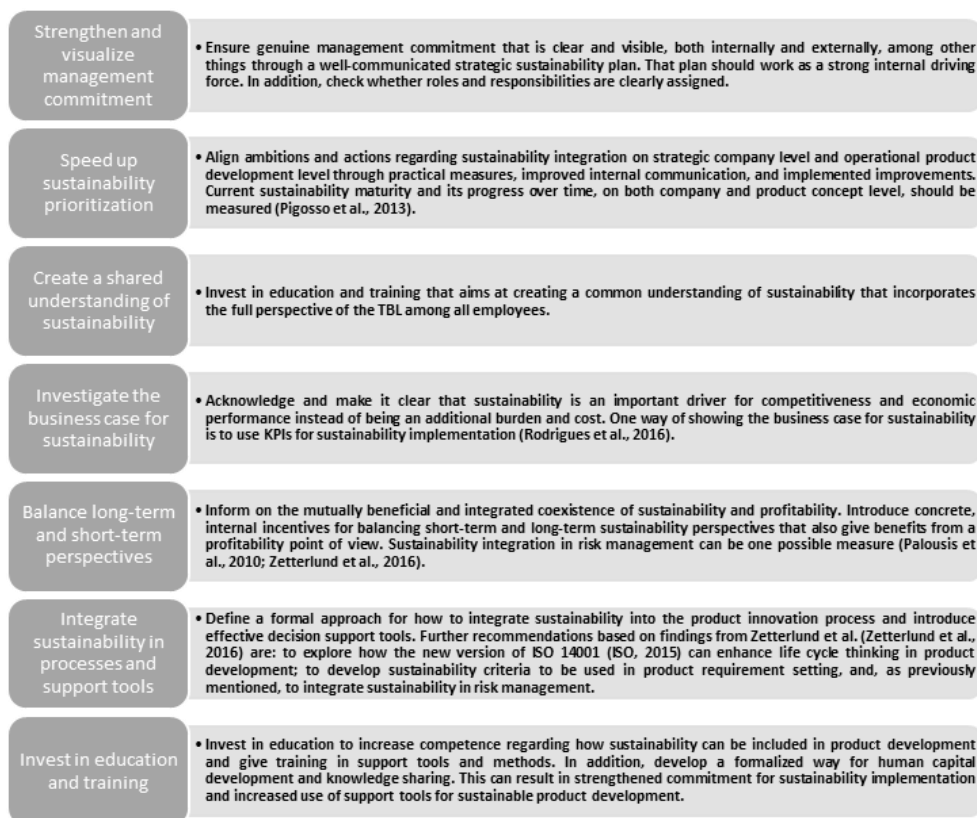
Strengthen and visualize management commitment	• Ensure genuine management commitment that is clear and visible, both internally and externally, among other things through a well-communicated strategic sustainability plan. That plan should work as a strong internal driving force. In addition, check whether roles and responsibilities are clearly assigned.
Speed up sustainability prioritization	• Align ambitions and actions regarding sustainability integration on strategic company level and operational product development level through practical measures, improved internal communication, and implemented improvements. Current sustainability maturity and its progress over time, on both company and product concept level, should be measured (Pigosso et al., 2013).
Create a shared understanding of sustainability	• Invest in education and training that aims at creating a common understanding of sustainability that incorporates the full perspective of the TBL among all employees.
Investigate the business case for sustainability	• Acknowledge and make it clear that sustainability is an important driver for competitiveness and economic performance instead of being an additional burden and cost. One way of showing the business case for sustainability is to use KPIs for sustainability implementation (Rodrigues et al., 2016).
Balance long-term and short-term perspectives	• Inform on the mutually beneficial and integrated coexistence of sustainability and profitability. Introduce concrete, internal incentives for balancing short-term and long-term sustainability perspectives that also give benefits from a profitability point of view. Sustainability integration in risk management can be one possible measure (Palousis et al., 2010; Zetterlund et al., 2016).
Integrate sustainability in processes and support tools	• Define a formal approach for how to integrate sustainability into the product innovation process and introduce effective decision support tools. Further recommendations based on findings from Zetterlund et al. (Zetterlund et al., 2016) are: to explore how the new version of ISO 14001 (ISO, 2015) can enhance life cycle thinking in product development; to develop sustainability criteria to be used in product requirement setting, and, as previously mentioned, to integrate sustainability in risk management.
Invest in education and training	• Invest in education to increase competence regarding how sustainability can be included in product development and give training in support tools and methods. In addition, develop a formalized way for human capital development and knowledge sharing. This can result in strengthened commitment for sustainability implementation and increased use of support tools for sustainable product development.

Figure 4: Key steps for companies to further improve capabilities for sustainability integration.

5 CONCLUSIONS

To successfully integrate sustainability in product development is a complex task, which requires thorough understanding and considerable changes on strategic, tactical and operational levels. This study has identified some common preconditions and challenges regarding sustainability integration in the product innovation process. The ambition was to present some prescriptive improvement recommendations based on the descriptive results of the questionnaire in order to clarify what the results mean and what implications they can have in practice for companies. The findings also provide guidance for the direction of future research and can be used for generic hypothesis testing. The substantial

empirical basis with more than 300 respondents, who all work actively with product development, provides a solid foundation for more prescriptive studies in the field.

Overall, with some exceptions, the results are quite similar for the different companies, which means that they share many preconditions and challenges. The main conclusions are that (i) increased capability for sustainability integration is perceived as decisive for future success of the company; (ii) environmental and social issues are not perceived to be correspondingly high prioritized today; (iii) the main driving force is an economic business case in the form of long-term competitiveness, but to some degree even legal and customer requirements, as well as environmental concern and reputation, are pushing company actions; (iv) there is no common understanding of sustainability at the companies and there is a strong focus on material selection and energy efficiency, while a full socio-ecological perspective is missing; (v) decision support systems are only used by half of the respondents and these systems are mostly simple tools such as checklists that are more widely used (vi) common challenges include a focus on short-term economic thinking, lack of effective decision support tools and knowledge, and vague management commitment; (vii) the development of sustainability criteria and more education and training are frequently stated improvement suggestions; (viii) sustainability training had significant positive effects on employees' attitudes and usage of formal decision support tools. Feedback from the companies confirmed these conclusions.

Further research is needed that goes beyond explorative and descriptive questionnaire and interview studies. Ongoing prescriptive research is therefore focusing on finding ways that enable companies to assess their current sustainability capability, to measure progress over time and to take strategic action towards sustainability integration on strategic, tactical and operational levels.

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