CHALLENGES FOR INTEGRATING SUSTAINABILITY IN RISK MANAGEMENT – CURRENT STATE OF RESEARCH

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Abstract

Numerous examples have shown how environmental and social issues can affect companies to an existential level. In fact, today's most urgent business risks, e.g. brand value, legislative change, litigation, and supply chain disruptions, are directly linked to sustainability issues. These risks need to be systematically identified and strategically managed on both strategic company- and operational product development level in order for a company to be long-term competitive. Based on literature review and interviews at case companies, this paper investigates the current state for integrating a strategic sustainability perspective in risk management processes and related support tools. Results show that sustainability risks are not consciously identified and managed at the companies. Research is at an early stage and few frameworks and tools exist. Based on the findings, the study identifies and provides a comprehensive analysis of challenges for sustainability integration, which work as a foundation for future research. Finally, key steps to advance understanding and methods in sustainability risk management are suggested.

Keywords: Risk management, Sustainability, Ecodesign, Sustainable product development, Strategic sustainable development

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1 INTRODUCTION

The transformation of society towards sustainability requires a transformation of companies and their products and services. In relation to product innovation, there are several mechanisms to facilitate this transformation to happen, such as eco-labelling, environmental management systems (e.g. ISO 14001), Corporate Social Responsibility (CSR), extended producer responsibility as well as guidance for social sustainability (e.g. ISO 26000) (Hallstedt et al., 2013). There is, however, not only a societal interest in pushing companies to develop more sustainable products. Many corporate leaders have started to acknowledge the business case for sustainability (Willard, 2012) and empirical studies indicate a positive effect of sustainable product innovation on overall company performance (Chen et al., 2006; Küçükoğlu and Pınar, 2015). At the same time, there are still considerable challenges that have to be overcome, including the imbalance between short-term and long-term profitability, a lack of a shared understanding of what sustainability means, as well as insufficient guidance and tools on how to translate strategic commitment into day-to-day action (Høgevold et al., 2014; Schulte and Hallstedt, 2017). More effective risk management, that mitigates threats and exploits opportunities, which is a prerequisite for long-term competitiveness and success, has been pointed out as a key area of research to overcome some of the challenges (Zetterlund et al., 2016). In fact, 8 out of the top 10 business risks today are directly linked to sustainability issues, Table 1. Some of these major risks are customer and consumer requests, environmental and social legislation, effects on reputation, ability to attract and retain top talent, and employee motivation (Bansal and Roth, 2000; Dangelico and Pujari, 2010; Neville et al., 2006). The recent risk report by the World Economic Forum also highlights the importance and interconnectedness of socio-ecological risks and other risks such as economic ones (WEF, 2017). In product design, decisions on for example material selection are most often made in early phases of product development, which has a decisive influence on the other parts of the product's life. If the unique properties desired rely on material compositions that risk to become critical, this means a business risk for the manufacturer. Limited availability, for example, drives an increase of the material price and high environmental impacts of materials face legislative restraints or have negative consequences from a market perspective. For the company, this is a risk that will threaten profitability. In Lloyd et al. (2012), this situation is defined as "environmental business risk". The research on sustainability aspects in risk management is, however, at an early stage. In order to be able to advance existing frameworks and to develop effective decision support tools, one has to first understand and identify current research gaps and the distinctive characteristics of sustainability risks. The purpose of this study is, therefore, to analyse existing work on the state of the art of sustainability risks, both on a conceptual level and in relation to integration into risk management processes and support tools. Thereby, this work aims at identifying preconditions and challenges for sustainability risk management that can guide future research. Based on the findings, a number of key steps for advancing this research area are suggested.

Table 1. Eight out of ten of the most important business risks are directly related to sustainability issues

	Top 10 risks (Aon, 2015)	Examples of sustainability related threats	Examples of sustainability related opportunities
1.	Reputation/brand	Negative publicity, scandals, boycotts, e.g. Citigroup, Nike, ExxonMobil, Shell, Nestle, Coca-Cola, PepsiCo	Increased brand value, strategic positioning of the brand, e.g. Patagonia, The Body Shop, Unilever, 3M
2.	Economic slowdown	No direct sustainability connection	
3.	Regulatory/legislative changes	Social or environmental legislation may lead to increased costs, e.g. energy- and carbon taxes, REACH.	Proactivity can result in competitive advantage when being ahead of legislation while competitors struggle, e.g. Electrolux
4.	Increasing competition	Low sustainability performance may lead to lower competitiveness	Increasing demand for more sustainable products. Sustainability as a value driver and competitive advantage.
5.	Attract or retain top talent	Meaning-making and contributing to a good cause becomes more and more important when professionals choose their jobs and career paths.	
6.	Challenge to innovate/meet customer needs	Intangible properties are more and more important, e.g. VIPP is selling trash bins and toilet brushes for several hundred euro per piece. Sustainability is one of the most important intangibles. Increasing customer demand for more sustainable products.	
7.	Business interruption	Supply chain disruptions (e.g. dependence on rare substances), boycotts, accidents etc.	More resilient operations and supply chains.
8.	Third-party liability	Fines, settlements, lost (social) license to operate	Minimized probability and consequences of third-party liability events
9.	Computer crime	No direct sustainability connection	
10.	Property damage	Riots and sabotage due to social opposition, extreme weather events	Minimized probability and consequences of property damage

The following research questions (RQ) are addressed in this study:

RQ1: What is the current state of research regarding sustainability risk management on the strategic enterprise level and the operational product level?

RQ2: What are the main research gaps and challenges for integrating a sustainability perspective into risk management?

By addressing these questions, the main contribution of this paper is a comprehensive overview and analysis of the current state and the challenges that in part are due to inherent properties of sustainability risks and in part due to research gaps and lack of knowledge.

2 BACKGROUND

2.1 Risk management in an organizational context

Risk can be defined as the effect of uncertainty on objectives, including both threats and opportunities (ISO, 2009). Both uncertainty and objectives exist on and are interconnected between the strategic, tactical, and operational levels of a company, which requires processes and tools to manage risks on all these levels, Figure 1. Thus, risks in product development cannot be managed in total isolation from strategic and tactical risks and objectives. For example, significant risks on the operational product development level need to flow upwards through the organizational levels as they might require strategic or tactical responses. Similarly, some strategic objectives and risks need to be considered in product development. This is especially true for sustainability risks. For this reason, we have chosen to initially focus on sustainability integration in enterprise risk management (ERM) on the strategic level and product risk management on the operational level. Our focus also lies on possible connections between those two, and how they relate to goals and objectives.

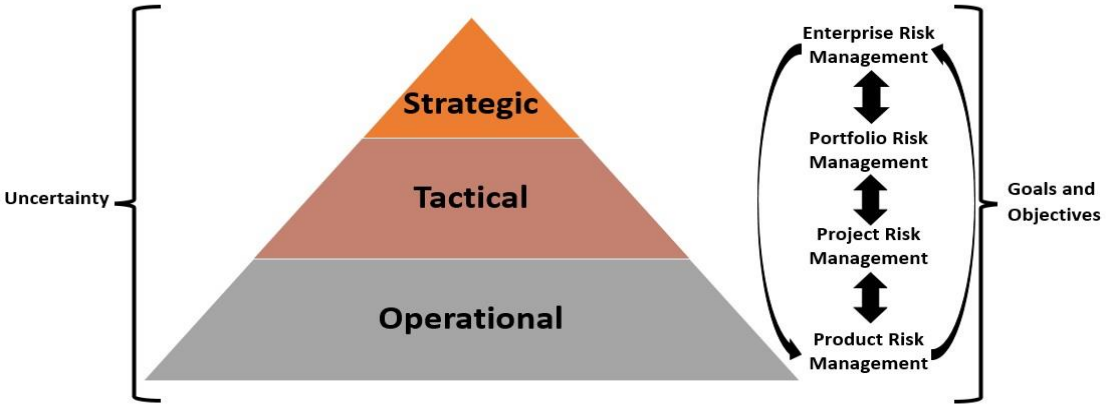

Figure 1. There are objectives, which are subject to uncertainty, on all levels of an organization. This requires interconnected risk management processes and tools

2.2 Sustainable Product Development to avoid risks

Many advanced and complex product solutions need to be supported in the market for a significant period of time and dependencies on unsustainable solutions come with a risk for the company, with possible effects on long-term reputation and image, investment plans, quality control, and efficiency. Sustainable product development (*hear meaning that a strategic sustainability perspective is integrated and implemented into the early phases of the product innovation process, including life cycle thinking*) aims to support product development companies to be proactive and avoid the risks mentioned. A combination of a forecasting and a backcasting approach is needed, which has the advantage of including aspects of today together with risk aspects of the suggested solution from a future sustainable society perspective (Hallstedt, 2017). The long-term perspective is not normally considered in support tools used in product development teams, which makes it harder to take actions today for issues that might come up later (Hallstedt et al., 2013). At the same time, development towards a sustainable society needs a long-time planning perspective. Lozano (2008) stated that a longer time perspective is important as a dimension in the understanding of sustainability, but it is not clearly covered in most of the used representations of sustainability. A framework for strategic sustainable development (FSSD) has been presented that uses backcasting from basic sustainability

principles (SPs) (Broman and Robèrt, 2017). By means of such a distinct definition of a sustainable solution, guidance on how to work towards that sustainable vision in a strategic, step-by-step way, can be identified. This is different from traditional eco-design, which focuses on simply decreasing the environmental impact of a product or service (Hallstedt et al., 2013).

3 METHOD

While there is plenty of research on risk management, general trends and state of the art, rather little attention has been focused on sustainability aspects in risk management in relation to business and product development. For that reason, an exploratory approach was taken (Karlsson et al., 2009). A review of the literature was performed to map the current state and conceptual challenges, as well as research gaps. This was complemented by semi-structured interviews of four risk managers, responsible for either enterprise- or product risk management processes in two large product development and manufacturing companies in Sweden. The questions focused on the following areas: current risk management processes and connections between them, support tools, and perceived benefits and challenges for risk management in general and for sustainability integration in specific. As a variety of sources is influential within the risk management discipline, the literature review was not restricted to journal and conference articles, but also included company-, interest organisation-, and consultancy reports, influential risk management books, and relevant ISO standards (31000, 14000, and 9000 series). Snowballing was also used to be observant of publications that are relevant for but that are not precisely within the field of sustainability risk management. Web of Science and Scopus databases were used. Components of the search strings included key words and synonyms for risk management, sustainability, and product development. The selection and analysis of the sources was carried out, following guidance by Blessing and Chakrabarti (2009) and Karlsson et al. (2009): for academic sources, the selection process started by reading the title, and then, dependent on the degree of relevance, abstract, introduction and conclusions, results, and finally background, objectives and setup were also read. Key attributes as well as a summary of each source were documented in an Excel spreadsheet, including year of publication, authors, risk discipline addressed, degree of relevance, main findings, keywords etc. Of a total of approximately 300 articles, about 70 academic papers and 20 other sources were studied and analysed in full text.

4 RESULTS AND DISCUSSION

There is no commonly agreed upon definition of what sustainability risks are, nor how to identify them. Anderson (2006); in Palousis et al. (2008) defines them as the risks that result from environmental or social justice issues. This, however, then leaves the question of how environmental and social justice issues are defined. Palousis et al. (2008) present six categories of sustainability risks, ranging from (i) physical risks like business disruption through extreme weather events; over (ii) regulatory; (iii) litigation; (iv) competitiveness; and (v) reputational risks, to (vi) supply chain risks.

4.1 RQ1: Current state of sustainability integration in risk management

4.1.1 Enterprise Risk Management

What became evident in the interviews is that some of the more obvious sustainability risks already are widely considered, e.g., legislative change and extreme weather events. These risks are, however, not consciously and systematically identified and managed as sustainability risks as such. Instead, they are identified rather by chance when investigating other risk categories. Thus, it is likely that important sustainability risks are missed, leaving companies vulnerable to threats and missing out on opportunities.

In the literature, the importance of integrating a sustainability perspective into ERM is increasingly acknowledged and a number of suggestions for new frameworks (Giannakis and Papadopoulos, 2016; Saardchom, 2013; Yilmaz and Flouris, 2010) and sustainability integration into existing ones (Aon, 2007; Faris et al., 2013; Lam and Quinn, 2014; Pollard and Stephen, 2008) have been made. The existing frameworks generally accommodate sustainability risks well on a conceptual level, without major changes in their structure. Sustainability rather adds an additional dimension to ERM. While the proposed frameworks are similar to a large degree, there are also some important marks of distinction. Faris et al. (2013) consider that a sustainability perspective adds to the range of possible risks that can

affect organizational objectives. In contrast, Aon (2007) and Saardchom (2013) argue that sustainability should be a separate objective. In regard to the connection between strategic, tactical and operational levels, Lam and Quinn (2014) point out that dashboard reports could be a valuable tool. In a feedback loop, risk information would flow up to senior management and the board, who would then study implications and take decisions, which would be passed down to the business units to take action.

Kytle and Ruggie (2005) stress the importance of managing stakeholder relations, which they think is key for managing social risks. However, their argumentation is to a large degree also valid for environmental risks. Managing relationships differs from simply managing stakeholders, which is about "the dissemination of information to stakeholders, through public relations or community relations, on decisions already made without completing the feedback loop" (Kytle and Ruggie, 2005), while managing stakeholder relationships requires closing the loop and truly engaging stakeholders. This means that stakeholders are approached, listened to, and involved in decision making or in finding solutions. The advantage of engaging relevant stakeholders to a high degree is that the engagement often is mutual, meaning that if the company chooses to involve stakeholders in some company decisions, these stakeholders may also involve the company in their decision making, e.g., regarding regulation, NGO campaigns etc. This two-way engagement also provides the company with antennae through which signals of rising issues and challenges can be picked up, as well as information on early possible responses. These ambitions need to be linked to the company's strategic risk management (Kytle and Ruggie, 2005).

4.1.2 Product risk management

Palousis et al. (2010, 2008) have presented the so far most comprehensive framework, called sustainability risk assessment, which specifically addresses product development. They use an integrated bottom line (IBL) perspective for identifying sustainability risks. In contrast to the triple bottom line (TBL) (Elkington, 1997), where economic, social, and environmental aspects are considered as separate and equally important dimensions, in the IBL, social and environmental aspects are functions of the economic domain. The sustainability risk assessment framework is based on this thinking (Palousis et al., 2010). Therefore, the identification of sustainability risks is tied to a line of cause and effect, which connects the environmental and social domains with the economic one. The simple fact that a product has an environmental or social impact in the different stages of its life cycle does not automatically mean that all these impacts are sustainability risks. For the sustainability impact to be considered as a sustainability risk, three conditions must be met: first that impact has to be considered as part of an unsustainable trend; second, the government or global community has to take action on that trend, and third, this action has to have a direct or indirect effect on the product's life cycle cost (LCC). As an example, climate change is an unsustainable trend and several regulations that affect the product's LCC are in place and can be expected to become tougher in the future. These trends that make the link between environmental impacts and economic effects are investigated based on the same time perspective as the life cycle of the product. The methodology that Palousis et al. (2010) suggest is based on a combination of life cycle assessment (LCA) and activity-based life cycle costing. The chains of cause and effect are assessed and visualized as sustainability risk trees. The risk trees can then be used to make risk statements, for example: acidification due to NOx emissions, leading to tougher political action on cutting emissions, leading to NOx taxes, leading to more expensive transports, leading to higher costs in the supply chain and distribution. After the identification of the risk statements, a quantitative risk analysis is applied to calculate the potential impact of the sustainability risks on the product's LCC by multiplication of probability and consequences. This results in the final output, the sustainability-adjusted LCC of a product, that can be used to improve the design by, for example, substituting critical materials to decrease sustainability risks or to choose between different design alternatives.

Several approaches to integrate environmental aspects into FMEA have been made. The method suggested by Rozak et al. (2015) is, however, very narrow in scope, and is limited to risks for non-compliance with environmental legislation with focus on failure of machines or equipment. This is, though, only a fraction of relevant sustainability aspects. In addition, using regulation as the point of reference is a very passive, minimum approach. Lindahl (1999) suggested a more thorough approach to be used in the early phases of product development, including the following steps: (i) identification of the life cycle stages of the product or process and of the connected activities; (ii) identification of

environmental aspects, e.g., emissions to air and water; (iii) linking environmental impacts caused by each environmental aspect; (iv) evaluation of environmental aspects and impacts that should be regarded as significant, using public image, controlling documents, and environmental consequences as criteria; (v) listing of recommended actions. This approach is more systematic and takes the whole life cycle into account as well as input from multiple sources, not only regulation. Applying this method in the early stages has several advantages including there being larger differences between different concepts compared to differences on a detailed component level. Also, changes that can reduce environmental failure modes are easier to make in the early stages. Still, it does not include a full strategic sustainability perspective and social aspects are not considered at all. Also, the connection between the failure modes or environmental impact and value or financial loss is vague. The approach has also been criticised for its limiting scope in space and time (Lenzen et al., 2003). Finally, it is also unclear how aspects and impacts can be identified and assessed in a systematic way, as there is no underlying definition of it. Hallstedt et al. (2015) have therefore suggested to complement the method with a strategic sustainable assessment and net present value analysis. Herva et al. (2011) presented a case study that combines ecological footprint (EF) with environmental risk assessment (ERA) to make decisions in the design of child footwear. The scope of ERA is, however, limited to health risks due to the exposure to hazardous compounds. The connection to potential effects on company objectives does not form part of neither EF or ERA, which makes the choice between design alternatives in product development difficult. In a recent study, Gargalo et al. (2016) suggested a multi-level framework for techno-economic and environmental sustainability analysis through risk assessment to be used in early product development. A framework for a sustainability risk assessment of mechanical systems in the concept design phase was presented by Anand et al. (2016). It is based on the identification and analysis of so called sustainability risk assessment parameters. A newly developed index is then used to evaluate different design alternatives from a risk perspective.

4.2 RQ2: Challenges for sustainability integration in risk management

Based on the insights from the interviews and reviewed literature, we argue that there are two types of challenges for effectively managing sustainability risks. First, sustainability risks have some inherent properties that differentiate them from the more traditional risks and that are the root causes for the main challenges in integrating them into risk management processes, no matter if it is on enterprise or product level. Just like with aleatory uncertainty, these challenges cannot be solved or reduced, but only managed as well as possible. Second, there is a number of challenges that are due to research gaps and lack of knowledge. Like epistemic uncertainty, these challenges can be overcome through further investigations, testing, and learning, for example, through development and application of new tools, process changes etc. The identified challenges do not exclusively apply only for sustainability risks; the combination of them, however, makes sustainability issues one of the most difficult aspects to manage.

4.2.1 Challenges due to inherent sustainability risk properties

Temporal dynamics: Like for some other types of risks, the connection between short-term and long-term sustainability risks is often vague (Bromiley et al., 2015). Still, this connection is of great importance: if product lifespan is short, the company may be blind for significant longer-term risks. If the lifespan is long, the company has to identify the long-term risks of present choices. The challenge is to balance the time perspective of sustainability risk management in order to be long-term sustainable and short-term profitable.

Qualitative dimension: The concept of "sustainability" is based on ethics and value judgement, e.g., why society should care about sustainability, other species and future generations. This is also evident in product development and risk management: for example, what sustainability impact is more serious, the emission of 50 kg of lead, or 1000 hours of child labour? In addition, there are dimensions of sustainability that cannot meaningfully be expressed in quantitative terms without reduction, for example, the aesthetic value of a landscape. As a result, rational or objective decisions are not possible, neither is the complete quantification of the sustainability impact. This, however, does not imply that a thorough investigation and assessment of sustainability aspects is impossible or useless. What it means is that quantitative and qualitative approaches have to be combined to create an as good as possible basis for decision making. Still, it is important to keep in mind that the decision includes some degree of value judgement and might be based on expert judgement of sustainability risks.

Handling this qualitative dimension poses a great challenge for both risk management and sustainable product development in general, especially in the later phases of product development, where the requirement for quantitative parameters is high.

Deep uncertainty: Neither the probabilities nor consequences of many sustainability-related events are assessable with any reasonable precision (Pollard and Stephen, 2008), which means that "traditional statistical methods and tools are not suitable, as relevant supporting models cannot easily be justified and relevant data are missing" (Aven, 2013). Quantification is in such cases rather a risk, because the numbers might create a false sense of certainty. In addition, the numbers do not catch the qualitative aspects as discussed above, meaning that important aspects can be missed. The resulting challenge is that it is difficult to express sustainability risks in numbers and to connect them with other attributes such as profitability. This, in turn, makes it hard to define quantitative goals, decide on risk responses, and monitor and measure progress and effectiveness of responses. As pointed out by several interviewees, this difficulty in managing sustainability risks can result in these being simply ignored or that the importance of other, more tangible and quantifiable risks is given precedence. Cox (2012) reviewed 10 tools that can enhance the understanding of deep uncertainty and decision making when correct models are not known. The tools are based on two strategies, either finding robust decisions that work acceptably well for many models, or adaptive risk management, which means learning through well-designed and analysed trial and error. Similarly, Pollard and Stephen (2008) suggest adding "adaptation" as an appropriate risk response, which means decreasing company vulnerability and preparing for the unknown. Still, Aven (2013) points out that risk assessments and analyses do not prescribe what to do, they are merely a tool to inform the decision maker. Analyses are also based on assumptions, background knowledge with a degree of certainty, etc., and have to be viewed in a bigger context. This also poses the challenges of how results can be displayed in a way that reflects underlying assumptions and the degree of knowledge and certainty (Aven, 2016). Therefore, Aven (2013) argues that "a managerial review and judgement is required that can see beyond the narrow technical criteria when making judgements about the risk being acceptable or not". Risk acceptance criteria can help but not replace managerial judgement and decision making.

4.2.2 Research and managerial challenges

No clear and shared understanding of what sustainability means: Most of the existing work either refers to the Brundtland definition (WCED, 1987), the TBL, or uses some rather arbitrary categorization of sustainability risks. Neither is there a shared understanding at the companies, which, however, is a prerequisite, not only for effective communication, but also for being able to build capabilities and to define and identify sustainability risks (Schulte and Hallstedt, 2017).

Strategic perspective is missing: For ERM, the importance of closely tying it to strategic planning is widely noticed (Aon, 2010; Arena et al., 2010; Bromiley et al., 2015; Farrell and Gallagher, 2015). However, while there might be a sustainability perspective on strategy, a strategic perspective on sustainability risks is missing. For instance, only looking at the effects on a product's LCC does not provide any long-term strategic guidance. For that, a clear definition of a future state of full sustainability is required. Backcasting from SPs can foster such a perspective (Hallstedt et al., 2013).

Unclear responsibilities: The presence of a Chief Risk Officer (CRO) has been pointed out as a mark of distinction of successful ERM (Liebenberg and Hoyt, 2003; Yazid et al., 2011). This works fine as long as ERM mainly focuses on internal and controllable risks. Sustainability risks are, however, often external and therefore difficult to assign to any specific internal function. At the same time, sustainability issues are too complex and diverse as to expect the CEO or Board of Directors to be knowledgeable about them and to manage them (Pollard and Stephen, 2008).

Perceived inherent conflict between sustainability and financial goals: Even though there is emerging recognition of the mutually beneficial relationship between sustainability and traditional company goals (Willard, 2005), some still perceive a trade-off (Aon, 2007; Saardchom, 2013), instead of a symbiosis.

Vague connection to cost and value: As sustainability risks are complex, interrelated, and difficult to analyse quantitatively, their influence on costs and benefits is unclear. However, some interviewees point out the importance of understanding this connection from a company perspective, in order to make calculations on the return of investment and decide on appropriate risk responses.

Low overall ERM maturity: ERM as a discipline might be too immature and some necessary preconditions for sustainability integration might not be there, e.g., a basic understanding of what

ERM is, what role it should play at the company, and how it should be used. The current degree of implementation in general might also be insufficient for adding a sustainability perspective as a new dimension. This concern was also expressed in some of the initial interviews. On the other hand, coming in with sustainability at an early stage of the development of ERM and its implementation offers opportunities to achieve sustainability becoming a natural part of ERM instead of being tacked on to it later when the ERM fundamentals are more established.

Underdeveloped social dimension: Unsurprisingly, the social dimension of sustainability is particularly underdeveloped in current risk management practices, just as it is in sustainable product development in general (Hallstedt et al., 2013; Schulte and Hallstedt, 2017).

4.2.3 Sustainability: a lens or an objective?

Per definition, strategic planning starts with a vision of success and risk management starts with objectives. Therefore, it is important to be clear on how sustainability should be included in objective setting as the rest of the risk management process depends on it. There are two ways in which a sustainability perspective can relate to objectives. First, sustainability can be formulated as a new objective in itself, side by side with other objectives for financial performance, quality, etc. (Saardchom, 2013). Second, a sustainability perspective can be used as a lens through which existing objectives are viewed (Faris et al., 2013). Both approaches have strengths and drawbacks. Formulating specific sustainability objectives is a clear and tangible statement, which also symbolizes commitment. It is also more concrete and makes it possible to break down objectives into goals, key performance indicators, etc. On the other hand, sustainability should not be formulated as a specific objective if it is no objective in itself. In other words, if the company is only interested in sustainability aspects when they provide economical advantage, then sustainability aspects should not be stated as objectives. Another drawback is that if sustainability is an objective alongside many others, trade-offs arise and sustainability might get lower prioritization than other objectives, resulting in sustainability considerations only being done in good times, something which was also pointed out by an interviewee. In addition, treating sustainability as a separate objective can lead to important connections to other objectives being missed. The main advantage of using sustainability as a lens is that the connections between sustainability and other objectives are at the centre. In this case, there does not have to be trade-offs, sustainability can, instead, be seen as a tool to reach other objectives, including financial ones. The main drawback is that, at least initially, sustainability is less concrete and the connections to other risks can be difficult to identify without guidance and training. Hallstedt (2017) has presented a suggestion for how sustainability can be defined for company products.

Obviously, the strengths of one approach are the drawbacks of the other and vice versa. The question is, therefore, if these two approaches can and should be combined. This would mean that there is both a distinct sustainability objective, but at the same time a sustainability lens is also applied to view all other objectives. This approach could potentially combine the strengths of both ways. However, it could also lead to confusion. More research, both on a conceptual and an empirical level, is needed to investigate more in detail if such an approach would work in practice and, in that case, what it would look like.

5 CONCLUSIONS

Research on integrating a sustainability perspective in risk management is at an early stage. Few systematic methods for identifying and managing sustainability risks exist and those that do also have significant limitations. In practice, at least at the case companies that were part of this study, there are neither processes nor tools for managing sustainability risks in place today. However, in contrast to Saardchom (2013), we consider that existing risk management frameworks, such as ISO 31000 and COSO's ERM framework, generally go together well with sustainability issues and that there is no conflict between these frameworks and including sustainability aspects in risk management. However, one has to remember that these frameworks are merely vessels that provide some general guidance and structure – filling them with content is a different task and not the purpose of the frameworks.

Based on interviews and literature review, numerous barriers for sustainability risk management were identified and grouped into two types; first, challenges that are due to inherent properties of sustainability risks, and second, research and managerial challenges. The findings will work as guidance for future research in the field. Some key steps should include: (i) development of a deeper

conceptual understanding of what sustainability risks are and how they could be managed strategically within an organizational context; (ii) more detailed empirical studies that look at the current state of practice to identify company needs and potentials for sustainability integration in risk management; (iii) mapping of existing general risk management tools and techniques and their potential for managing sustainability risks; (iv) development of a framework as well as tools for strategic sustainability risk management; (v) validating and testing of such approaches. Linking the FSSD to sustainability risk management could add a valuable perspective and methodology to overcome some of the most urgent identified challenges and, therefore, deserves closer investigation.

REFERENCES

Anand, A., Khan, R.A. and Wani, M.F. (2016), "Development of a sustainability risk assessment index of a mechanical system at conceptual design stage", *Journal of Cleaner Production*, Vol. 139, pp. 258–266.

Aon. (2007), Sustainability - Beyond Enterprise Risk Management, available at: http://www.aon.com/about-aon/intellectual-capital/attachments/risk-services/sustainability_beyond_enterprise_risk_management.pdf

Aon. (2010), *Global Enterprise Risk Management Survey*, Aon Corporation, Chicago, available at:https://doi.org/10.1002/jhrm.5600210106

Aon. (2015), *Global Risk Management Survey 2015*, available at: http://www.aon.com/2015GlobalRisk/attachments/2015-Global-Risk-Management-Report-230415.pdf

Arena, M., Arnaboldi, M. and Azzone, G. (2010), "The organizational dynamics of Enterprise Risk Management", *Accounting, Organizations and Society, Elsevier Ltd*, Vol. 35 No. 7, pp. 659–675.

Aven, T. (2013), "On How to Deal with Deep Uncertainties in a Risk Assessment and Management Context", *Risk Analysis*, Vol. 33 No. 12, pp. 2082–2091.

Aven, T. (2016), "Risk assessment and risk management: Review of recent advances on their foundation", *European Journal of Operational Research, Elsevier B.V.*, Vol. 253 No. 1, pp. 1–13.

Bansal, P. and Roth, K. (2000), "Why Companies Go Green : A Model of Ecological Responsiveness", *The Academy of Management Review*, Vol. 43 No. 4, pp. 717–736.

Blessing, L.T.M. and Chakrabarti, A. (2009), *DRM, a Design Research Methodology, Springer Dordrecht Heidelberg London New York*, available at:https://doi.org/10.1007/978-1-84882-587-1

Broman, G.I. and Robèrt, K.-H. (2017), "A Framework for Strategic Sustainable Development", *Journal of Cleaner Production*, Vol. 140, pp. 17–31.

Bromiley, P., McShane, M., Nair, A. and Rustambekov, E. (2015), "Enterprise Risk Management: Review, Critique, and Research Directions", *Long Range Planning, Elsevier Ltd*, Vol. 48 No. 4, pp. 265–276.

Chen, Y.S., Lai, S.B. and Wen, C.T. (2006), "The influence of green innovation performance on corporate advantage in Taiwan", *Journal of Business Ethics*, Vol. 67 No. 4, pp. 331–339.

Cox, L.A. (2012), "Confronting Deep Uncertainties in Risk Analysis", *Risk Analysis*, Vol. 32 No. 10, pp. 1607–1629.

Dangelico, R.M. and Pujari, D. (2010), "Mainstreaming green product innovation: Why and how companies integrate environmental sustainability", *Journal of Business Ethics*, Vol. 95 No. 3, pp. 471–486.

Elkington, J. (1997), *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*, Capstone, Oxford.

Faris, C., Gilbert, B., LeBlanc, B., Ballou, B. and Heitger, D.L. (2013), *Demystifying Sustainability Risk: Integrating the Triple Bottom Line into an Enterprise Risk Management Program*, Committee of Sponsoring Organizations of the Treadway Commission.

Farrell, M. and Gallagher, R. (2015), "The Valuation Implications of Enterprise Risk Management Maturity", *Journal of Risk and Insurance*, Vol. 82 No. 3, pp. 625–657.

Gargalo, C.L., Carvalho, A., Gernaey, K. V. and Sin, G. (2016), "A framework for techno-economic & environmental sustainability analysis by risk assessment for conceptual process evaluation", *Biochemical Engineering Journal*, Elsevier B.V., Vol. 116, pp. 146–156.

Giannakis, M. and Papadopoulos, T. (2016), "Supply chain sustainability: A risk management approach", *International Journal of Production Economics, Elsevier*, Vol. 171, pp. 455–470.

Hallstedt, S. (2017), "Sustainability Criteria and Sustainability Compliance Index for Decision Support in Product Development", *Journal of Cleaner Production, Elsevier Ltd*, Vol. 140 No. 1, pp. 251–266.

Hallstedt, S.I., Bertoni, M. and Isaksson, O. (2015), "Assessing Sustainability and Value of Manufacturing Processes: A case in the aerospace industry", *Journal of Cleaner Production, Elsevier Ltd*, Vol. 108, pp. 169–182.

Hallstedt, S.I., Thompson, A.W. and Lindahl, P. (2013), "Key elements for implementing a strategic sustainability perspective in the product innovation process", *Journal of Cleaner Production, Elsevier Ltd*, Vol. 51, pp. 277–288.

Herva, M., Álvarez, A. and Roca, E. (2011), "Sustainable and safe design of footwear integrating ecological footprint and risk criteria", *Journal of Hazardous Materials, Elsevier B.V.*, Vol. 192 No. 3, pp. 1876–1881.

Høgevold, N.M., Svensson, G., Wagner, B., J. Petzer, D., Klopper, H.B., Carlos Sosa Varela, J., Padin, C., et al. (2014), "Sustainable business models: Corporate reasons, economic effects, social boundaries, environmental actions and organizational challenges in sustainable business practices", *Baltic Journal of Management*, Vol. 9 No. 3, pp. 357–380.
ISO. (2009), ISO 31000: *Principles and Guidelines*.
Karlsson, C., Croom, S., Forza, C., Voss, C., Åhlström, P., Coughlan, P., Coghlan, D., et al. (2009), *Researching Operations Management*, edited by Karlsson, C.Researching Operations Management, Routledge, New York, available at:https://doi.org/10.4324/9780203886816
Küçükoğlu, M.T. and Pınar, R.İ. (2015), "Positive Influences of Green Innovation on Company Performance", *Procedia - Social and Behavioral Sciences*, Vol. 195, pp. 1232–1237.
Kytle, B. and Ruggie, J.G. (2005), *Corporate Social Responsibility as Risk Management: A Model for Multinationals, Corporate Social Responsibility Initiative Working Paper No. 10*, Cambridge, available at:https://doi.org/10.1111/1098-1616.00020
Lam, J. and Quinn, F. (2014), *The Role of Sustainability in Enterprise Risk Management*, available at: http://www.cees.ingersollrand.com/CEES_documents/Role_of_sustainability_in_enterprise_risk_management.pdf.
Lenzen, M., Murray, S.A., Korte, B. and Dey, C.J. (2003), "Environmental impact assessment including indirect effects - A case study using input-output analysis", *Environmental Impact Assessment Review*, Vol. 23 No. 3, pp. 263–282.
Liebenberg, A.P. and Hoyt, R.E. (2003), "The Determinants of Enterprise Risk Management: Evidence from the Appointment of Chief Risk Officers", *Risk Management and Insurance Review*, Vol. 6 No. 1, pp. 37–52.
Lindahl, M. (1999), "E-FMEA - A new Promising Tool for Efficient Design for Environment", *First International Symposium on Environmentally Conscious Design and Inverse Manufacturing*, pp. 734–740.
Lloyd, S., Lee, J., Clifton, A., Elghali, L. and France, C. (2012), "Ecodesign through Environmental Risk Management: A Focus on Critical Materials", *In Design for Innovative Value towards a Sustainable Society, Springer Netherlands*, pp. 374–379.
Lozano, R. (2008), "Envisioning sustainability three-dimensionally", *Journal of Cleaner Production*, Vol. 16 No. 17, pp. 1838–1846.
Neville, B.A., Bell, S.J. and Mengüç, B. (2006), "Corporate reputation, stakeholders and the social performance-financial performance relationship", *European Journal of Marketing*, Vol. 39 No. June 2016, pp. 1184–1201.
Palousis, N., Luong, L. and Abhary, K. (2008), "An integrated LCA/LCC framework for assessing product sustainability risk", *WIT Transactions on Information and Communication Technologies*, Vol. 39, pp. 121–128.
Palousis, N., Luong, L. and Abhary, K. (2010), "Sustainability risk identification in product development", *International Journal of Sustainable Engineering*, Vol. 3 No. 2, pp. 70–80.
Pollard, D. and Stephen, D.W. (2008), *Sustainability , Risk and Opportunity : A Holistic Approach*, Toronto, available at: http://www.accountingforsustainability.org/wp-content/uploads/2011/10/CICA-A-Holistic-Approach-Report.pdf
Rozak, M., Spilka, M. and Kania, A. (2015), "Environmental Failure Mode and Effects Analysis (Fmea) – A New Approach To Methodology", Metalurgija, Vol. 54 No. 2, pp. 449–451.
Saardchom, N. (2013), "Enterprise Risk Management under Sustainability Platform", *Journal of Business and Economics*, Vol. 4 No. 1, pp. 32–41.
Schulte, J. and Hallstedt, S.I. (2017), "Challenges and Preconditions to Build Capabilities for Sustainable Product Design", *Submitted to the 21st International Conference on Engineering Design*.
WCED. (1987), *Our Common Future: Report of the World Commision on Environement and Development*, Oxford Paperbacks, available at:https://doi.org/10.2307/2621529
WEF. (2017), *The Global Risks Report 2017 12th Edition*, Geneva.
Willard, B. (2005), T*he Next Sustainability Wave, New Society Publishers*, Gabriola Island.
Yazid, A.S., Razali, A.R. and Hussin, M.R. (2011), "Determinants of Enterprise Risk Management (ERM): A Proposed Framework for Malaysian Public Listed Companies", *International Business Research*, Vol. 5 No. 1, pp. 80–86.
Yilmaz, A. and Flouris, T. (2010), "Managing corporate sustainability: Risk management process based perspective", *African Journal of Business Management*, Vol. 4 No. 2, pp. 162–171.
Zetterlund, H., Hallstedt, S. and Broman, G. (2016), "Implementation potential of sustainability-oriented decision support in product development", *Proceedings of the 26th CIRP Design Conference*, Stockholm.

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