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Strategic Sustainability Risk Management in Product Development Companies: Key Aspects and Conceptual Approach

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Received: 23 November 2020; Accepted: 14 December 2020; Published: 16 December 2020

Abstract: Society's transition towards sustainability comes with radical change, which entails significant threats and opportunities for product development and manufacturing companies, for example related to new legislation, shifting customer preferences, and increasing raw material prices. Smart risk management therefore plays a key role for successfully maneuvering society's sustainability transition. However, from a company perspective, it remains challenging to connect the macro-level societal change with tangible risks for the business on the micro level. Based on interviews with academic and industrial experts, this study identified 21 key aspects for sustainability risk management. Drawing on these results and research from the areas of transition design, strategic sustainable development, and sustainability risk management, a conceptual approach for strategic risk management within the sustainability transition is presented. It builds on layered, double-flow scenario modelling in which backcasting from a vision, framed by basic principles for sustainability, is combined with forecasting from the present. The implications of such scenarios, i.e., risks, can then be identified and managed. By doing so on different scales, connections between macro- and micro-level change can be established. Thereby, product development companies shall be supported in making sustainability an intrinsic part of decision-making across the strategic, tactical, and operational levels to increase competitiveness while contributing to the transition towards a sustainable society.

Keywords: sustainable product development; backcasting; strategic sustainable development; transition design; Environmental Social and Governance (ESG)

1. Introduction

From a societal perspective, it is crucial that product development companies accelerate their sustainability-related efforts. They play a decisive role in the transition towards a sustainable society, not only because products and services cause immense use of resources and energy during their life-cycle [1], but also because it is in product development that the social meaning and the role of products within the larger system starts to form [2]. However, what are the implications of this macro-level transition for companies and their product development and manufacturing activities on the micro level? There has been extensive research on the connection between Environmental, Social, and Governance (ESG) and financial performance of companies, going back as far as to the early 1970s. Even though the aggregated empirical evidence suggests that there is a positive correlation between the two factors, the question of whether it "pays to be green" has not received a definite answer [3–5]. However, shifting towards sustainable business practices is inevitable in the long term if human society's continuation on this planet is to be ensured [6]. Therefore, the most relevant question is not if, but rather what, when, and how sustainability initiatives should be pursued by companies.

Being too passive or investing in sustainability initiatives that are not strategic can become costly in the face of, for example, legislative change, shifting customer demands, or because of reputational damage. On the other hand, it can be just as costly to be too proactive, for example when large amounts of resources are spent on products that are performing well from a sustainability perspective, but that are too costly or where there is not enough customer demand yet. Hence, the challenge is how companies can strike a balance and thereby reap business benefits, while contributing to society's transition towards a sustainable state [7]. Sustainable product development is defined as the integration and implementation of such a strategic sustainability perspective in the early phases of the product innovation process, including life-cycle thinking [8].

A risk management lens has been pointed out as a constructive way to engage in a more hands-on manner with companies around the business benefits related to sustainability aspects and to understand and address the implications of the ongoing transition of the societal system on the macro level for companies and product development on the micro level [6]. The main potential of applying a risk management approach is that it can use a familiar language and process to highlight the motivation and driving forces for sustainability in terms of both threats and opportunities on different organizational levels of the company. Such risks can be related to, for example, reputation, the ability to attract investment and talented employees, supply chain resilience, and raw material and energy costs [1,9,10]. However, questions remain both in relation to the theoretical concept of sustainability risk management as such and in relation to processes and tools for applying it in practice. Especially, research on the connection between sustainability risk management, transition design, and strategic sustainable development is scarce. Therefore, the following research questions are addressed:

- What are key aspects for successful sustainability risk management in a product development company context?
- How can a risk management lens be used to understand the implications of macro-level societal change on micro-level product development company objectives on different levels of decision-making?

By addressing these questions, the study has three aims: (i) to identify aspects that are essential for sustainability risk management in a product development company context and that can function as concrete recommendations for practitioners; (ii) to validate the sustainability risk definition and hypotheses proposed in an earlier study by Schulte and Hallstedt [6]; and (iii) to develop a conceptual approach that can support companies in finding and maneuvering the smart zone between being too passive and too proactive in relation to sustainability.

2. Background

This research draws on findings and theory from three main areas, which are transition design, strategic sustainable development, and sustainability risk management.

2.1. Transition Design

A transition can be defined as "a long term process—it may take one or more generations—of non-linear social change leading to new constellations of actors, structures and practices, which determine the functioning of the system" [11]. For a transition towards sustainability to happen, system innovations are required, i.e., one socio-technical system transitioning into another [12]. This can also be viewed as a design challenge, where sustainability is used as a meta-objective [13]. For understanding system innovations, which happen within a complex interplay of forces and change on different levels, a multi-level perspective (MLP) is necessary. The MLP proposed by Geels [12] includes three levels: (i) the macro level (also referred to as landscape), which includes the high-level structures in terms of, for example, culture, macro-politics, and macro-economics. Change on this level is usually slow and cannot be forced by single actors. This level provides the landscape for (ii) the meso level (also referred to as regimes). This level is about the rules and regimes of societal activities in terms of, for example,

technology, science, and business activities. Here, the status quo is often enforced. This is different for (iii) the micro level (also referred to as niche level), where new innovations can be explored and tested, which may or may not be in line with the current socio-technical systems. It should be noted that the three levels have no sharp boundaries and represent a continuum rather than three distinct levels. Product development companies play a key role for systems innovation, because they can envision and create the solutions on the micro level that can shake established systems on the meso level and, over time, contribute to change on the macro level. At the same time, product development companies need to understand and anticipate change on the macro- and meso level in order to ensure relevance and competitiveness within the current and future socio-technical systems (Figure 1).

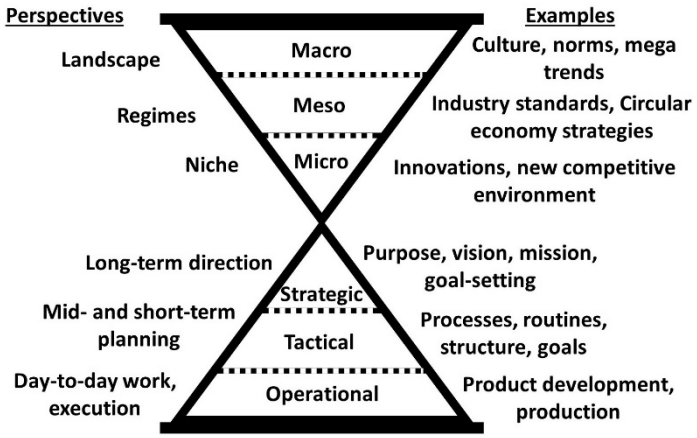

Figure 1. Change on the macro-, meso-, and micro levels comes with implications for the strategic, tactical and operational levels of a company.

Gaziulusoy et al. [2] presented a scenario method for how company teams in practice can link product development to visions of sustainability at the societal level to generate innovation pathways that respond to the systemic changes in the transition towards a sustainable society. The method, operationalized in the form of a 2-day workshop process, consists of three phases: Firstly, an understanding of the system and the interrelationships between the environment, society, and economy is created. This step also includes the identification of risks to sustainability of society, as well as mitigation measures. Secondly, after the creation of a societal vision in which the previously identified risks are mitigated, the workshop participants map exploratory as well as backcasting scenarios and identify aligning paths. Stakeholders with high influence on the scenarios are then incorporated into the map. Finally, product and service ideas are placed on the map, based on when they could be introduced. Thirdly, an action plan is created based on the results.

Scenario modelling and backcasting played a central role in research on transitions and system innovations since the very beginning [14]. However, it often remains unclear how visions of sustainable futures can be created that ensure that the vision is (i) socially and ecologically sustainable; (ii) sufficiently concrete to be able to backcast from it; (iii) not so detailed that it would easily become obsolete, for example in the face of technology advances; and (iv) possible for larger groups of people to agree on.

2.2. Strategic Sustainable Development

Both on a societal and on a company level, it is crucial to apply a strategic perspective when planning for, and working with, sustainable development. Otherwise, there is a risk that solutions and actions that might be better from a sustainability perspective compared to the status quo in the longer term turn out to be blind alleys on the way towards a fully sustainable state (Figure 2). For example, it is possible to increase efficiency and to reduce emissions of a gasoline engine, but there is no place for the gasoline engine in a fully sustainable society—it is a blind alley. To be able to be strategic (in any

context), it is necessary to know the desired outcome. In this case, a vision of a future sustainable society is necessary. Once such a vision is created, backcasting [15] can be applied to study which steps that are required to, over time, move towards the future vision. This is different from forecasting, which focuses on making predictions about what is likely to happen based on trends in the past with risks for path dependencies. Effective backcasting requires a vision which is neither too vague, not providing any practical guidance, nor too specific, limiting the solution space more than necessary and making it difficult for people to agree on the vision. Within the Framework for Strategic Sustainable Development (FSSD), which has a backcasting perspective at its core, basic principles for sustainability were derived with the aim of being necessary, sufficient, general, concrete, and non-overlapping, to provide a definition of an ecologically and socially sustainable society. They represent the root causes of unsustainability, up-streams in cause and effect chains. The sustainability principles (SPs) state that "*In a sustainable society, nature is not subject to systematically increasing (1) concentrations extracted from the Earth's crust, (2) concentrations of substances produced by society, (3) degradation by physical means; and people are not subject to structural obstacles to (4) health, (5) influence, (6) competence, (7) impartiality, and (8) meaning making*" [16].

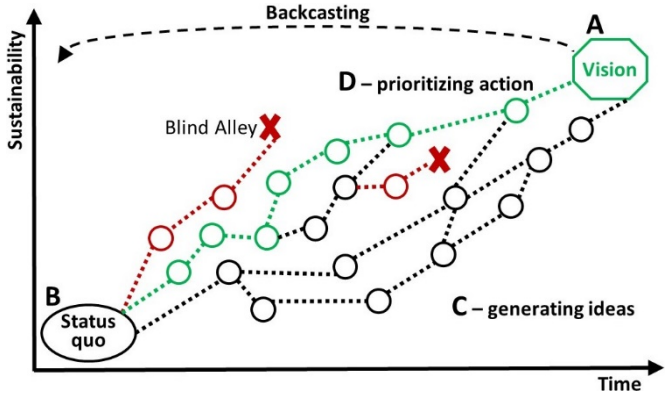

Figure 2. The ABCD procedure for strategic sustainable development.

When developing a vision, the principles can be used as boundary conditions, ensuring that the vision is in line with the basic requirements of sustainability, while not encroaching the solution space more than necessary [16]. However, there are drawbacks with applying a backcasting perspective alone, because that can lead to a so called "reality gap" in the present [2]. To avoid this, forecasting within a backcasting approach can complement a pure backcasting perspective, i.e., it is assessed what is likely to happen in the future based on existing trends, but this assessment is informed by the direction given by backcasting from a vision of success [16].

To support the application of strategic sustainability thinking in planning and decision-making contexts, the FSSD includes a four-step operational procedure, called ABCD. It starts by creating a vision framed by the sustainability principles (A), then the current situation is scrutinized through the lens of the vision (B), and possible solutions that could lead from the present towards the future are identified (C), before actions are prioritized and a roadmap is created (D) [16]. The FSSD and its operational procedure have been applied in a variety of contexts, including sustainable product development [8].

2.3. Sustainability Risk Management in Product Development Companies

In the ISO 31000 standard, risk is defined as the "effect of uncertainty on objectives" and a general process for risk management is presented, Figure 3 [17]. In product development companies, risk management is an established practice on both the strategic, tactical, and operational levels, and a variety of tools and methods exists [18]. However, risks related to social and environmental issues have not traditionally been included in a systematic way. Effective management of such

risks can yield significant benefits, such as operating cost reduction, proactive compliance with regulation and industry standards, improved stakeholder relations, and competitive advantages [19]. Hallikas et al. [20] further stressed the significance of sustainability practices in risk management. However, there are numerous challenges, partly due to the inherent properties of sustainability risks, e.g., related to temporal dynamics and qualitative aspects of sustainability, and partly due to lack of knowledge and support, e.g., for how to create a shared understanding of sustainability risk, and to make an appealing business case for sustainability risk management [21]. Additionally, dependency on unreliable sources, unpredictability of sustainability risks, methodological difficulties and subjectivity, and complexity and context-dependency are central obstacles for measuring sustainability risks [22]. Aziz and Manab [23] identified some success factors for sustainability risk implementation, such as senior management leadership, board oversight, and training.

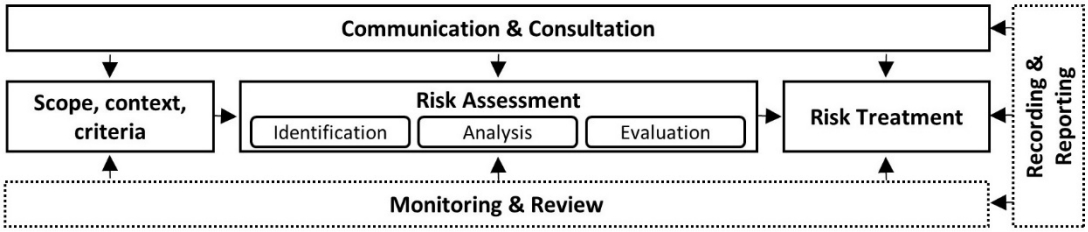

Figure 3. Risk management process based on ISO 31000.

Even though the general process for risk management, Figure 3, is applicable also for sustainability risks, they have properties that require a new perspective and companies need support to be able to understand, identify, and manage such risks in a strategic and systematic way. Hofmann et al. [24] and Hajmohammad and Vachon [25] studied sustainability risks in a supply chain context and used instrumental stakeholder theory to argue that sustainability risks are triggered by stakeholder reactions. This is in line with the findings by Lloyd et al. [26], who define environmental business risks as "'stakeholder responses to environmental impacts with the potential to cause harm to business objectives". Schulte and Hallstedt [6] also stress the importance of a stakeholder perspective and defined sustainability risks as "threats and opportunities that are due to an organization's contribution or counteraction to society's transition towards strategic sustainable development". This definition highlights that sustainability risks are highly dependent on the company's actions and practices in relation to the larger socio-technical system that the company is part of. In the same study, hypotheses regarding current practices and preconditions for sustainability integration in risk management were proposed. As the transition towards a sustainable society is ongoing, there are significant threats with inaction. Short et al. [27] argue that companies need to shift attitude from trying to minimize the effect of the transition on company economic value to proactively exploiting opportunities, which can positively affect both short- and long-term economic success.

Several tools and methods for sustainability risk management, specifically in product development, have been presented. Based on an integrated bottom-line perspective, Palousis et al. [28] presented a framework that combines Life Cycle Assessment (LCA) with Life Cycle Costing (LCC) to assess product sustainability risk. They later suggested so called sustainability risk trees as a tool for creating chains from (i) the product's life-cycle impacts; (ii) contribution of that impact to unsustainable societal trends; (iii) societal responses to such trends; and (iv) effects of these responses on the life-cycle cost of the product [29]. Another method is the sustainability assessment and value evaluation (SAVE), which combines a strategic sustainability assessment with net present value analysis to investigate the implications of different scenarios on manufacturing cost [30]. On the strategic level, attempts to integrate a sustainability perspective in enterprise risk management (ERM) have been presented, e.g., [31–34].

The connection between transitions and risk is the point of departure for the work by the Task Force for Climate-related Financial Disclosures (TCFD), which is providing voluntary advice for companies on how to disclose information to investors on how the company can be affected by society's transition towards a lower-carbon economy. Scenario analysis is specifically highlighted as a way for companies to explore how the future might look like and to identify and assess potential implications of a range of plausible future developments. The main benefits of scenario analysis, which can be qualitative or quantitative, are that it can (i) help consider issues that are highly uncertain, complex, affect both the short-, medium-, and long-term, and have potential disruptive effects; (ii) enhance companies' strategic conversations by broadening decision-makers thinking; (iii) help frame and assess the range of possible impacts on the company; (iv) help identify indicators to monitor the external environment; and (v) assist in understanding the robustness of a decision-making strategy. Thereby, companies can develop strategic plans that are more flexible and robust and that can more effectively manage transition risks. However, the TCFD points out that even though scenario analysis is a well-established practice for developing strategic plans, its use for understanding business implications of large-scale transitions is still at an early stage. Most scenarios address the global macro level change and there are challenges in how to connect such macro-level scenarios to a level that is closer to the company decision-making context [35]. Additionally, the TCFD focuses on climate change and does not include a full sustainability perspective. Neither does the scenario analysis necessarily include a strategic perspective in the sense of what was described in Section 2.2.

3. Methods

A qualitative research approach was applied, based on the interactive, systemic research design model proposed by Maxwell [36]. An overview of the research process is presented in Figure 4.

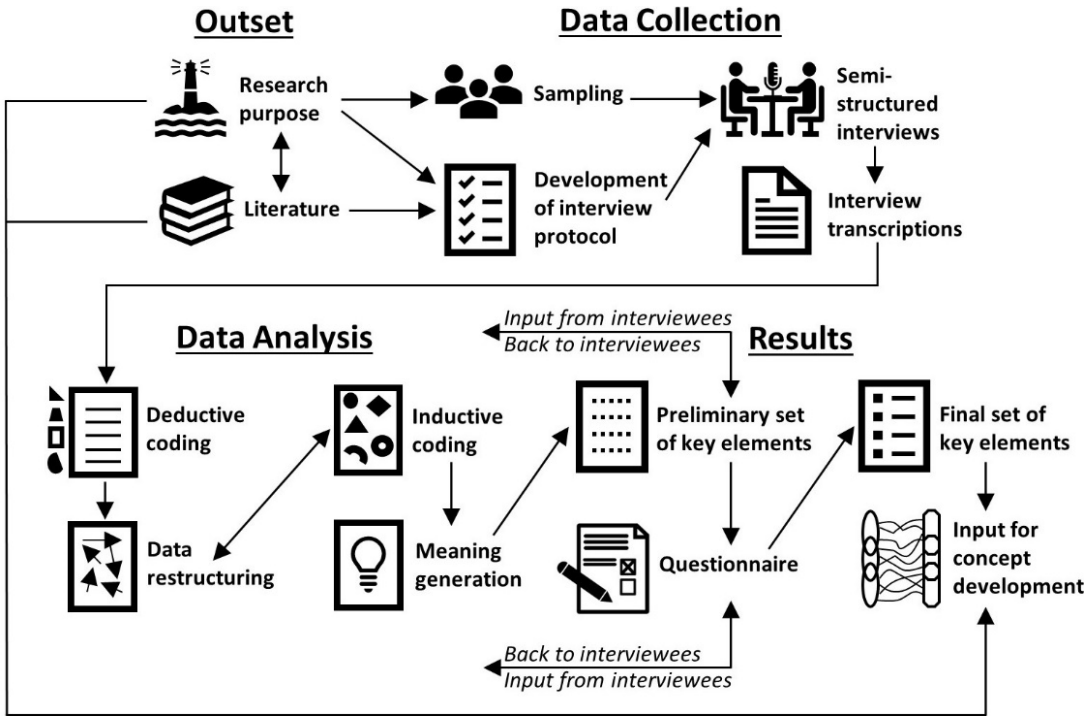

Figure 4. The main steps of the research process.

During the fall and winter of 2019, eight semi-structured interviews were conducted with academic and industrial experts. Purposeful sampling was applied, i.e., the interviewees were not selected randomly with the objective to be representative, but instead they were chosen based on their experience in the area of sustainability risk management. A list of potential interviewees was created. For the

academic experts, a previous literature review [6] was used to identify key researchers in the area. For the industrial experts, the sampling started with a review of sustainability reports by large product development and manufacturing companies in Sweden. In cases where the report made a clear connection between sustainability and risk management, the company's contact person was added to the list. The homepages of these companies were then reviewed, and snowballing was applied, which led to the identification of other companies, primarily consultancies. Hence, all consultancies included in the study work in a product development company context. Looking into homepages and documents by these consultancies led in turn to additional companies and contact persons being identified. Table 1 provides an overview of the interviewees, all of whom have long and extensive experience on sustainability risk management.

Table 1. Overview of interviewees included in this study.

Expert	Country	Sector
Industrial Expert 1	Sweden	Large company in the construction industry
Industrial Expert 2	UK	Small consultancy
Industrial Expert 3	Sweden	Large company in the furniture industry
Industrial Expert 4	Sweden	Large consultancy
Industrial Expert 5	Sweden	Small consultancy
Industrial Expert 6	Singapore	Large consultancy
Academic Expert 1	USA	University
Academic Expert 2	Finland	University

The interviews were semi-structured, i.e., following an interview protocol to provide structure and to ensure that all relevant topics are covered in every interview, but at the same time allowing for follow-up questions and adjustments based on the specific situation [37]. The interview protocol, Appendix A, was adjusted for each interview to fit the role and context within the interviewee was working [38]. Some general questions about the interviewee and his or her working tasks were used to open up the interview, followed by three main sections: (i) the concept 'sustainability risk management'; (ii) tools and methods; and (iii) challenges and success factors. Within each section, the questions started with pure inquiry, continued with exploratory diagnostic inquiry and concluded with confrontive inquiry. The steps of the risk management process, shown with solid lines in Figure 3, were used as a structure for the interviews. These steps were selected as the focus for this study because they form the necessary core of the process, which needs to be established before monitoring and review, as well as recording and reporting can take place.

Each interview lasted between 50 and 90 min and all interviews were recorded and transcribed. Qualitative data analysis was then conducted with two major rounds of coding. In the first round, a pre-defined set of codes was applied, which was based on the themes of the interviews and the steps of the ISO 31000 risk management process. This coding was then used for a first restructuring of the data, which provided the starting point for the second round of coding, this time using inductively derived codes with a higher level of detail. The process started by open coding where the data were read repeatedly and tentative labels for chunks of data were created based on the meaning that emerged from the data. This led to the creation and refinement of codes in an iterative process. Dual coding was allowed to enable multiple ways of restructuring the data [39]. Axial coding was then performed, where relationships between codes were identified and the data was restructured again. From there, the results of the analysis were synthesized before doing a final selective coding to check and refine the outcome [40]. Of the 13 tactics for generating meaning presented by Miles et al. [38], multiple were combined, primarily noting patterns, clustering, making contrasts and comparisons, subsuming particulars into the general, and making conceptual coherence. Based on the outcome of the analysis and informed by the literature, the results were synthesized into a preliminary set of key aspects. This first version was sent back to the interviewees alongside a questionnaire (Appendix B), which

had the purpose to validate and receive feedback on the findings, provide the opportunity for the interviewees to take part of the study results, and to identify needs and areas of interest for further research. In total, four of the eight interviewees responded and provided extensive qualitative feedback, which was analyzed with a single round of coding. The results led to the refinement of the key aspects. The development of a conceptual approach for strategic sustainability risk management took then place based on the identified key aspects and previous research within the areas of transition design, strategic sustainable development, and risk management.

4. Results

4.1. Key Aspects for Strategic Sustainability Risk Management

The purpose of this part of the study was (i) to identify key aspects for successful sustainability risk management in product development companies that can provide more detailed recommendations and guidance for researchers and practitioners; and (ii) to test the previously developed definition of sustainability risks [6]. This section describes the synthesized results of the interview analysis and uses quotes to give illustrative examples of the interviewees' own words. The structure of this section follows the selected steps of the ISO 31000 standard for risk management.

4.1.1. Sustainability Risk Scope

The interviewees were asked about their understanding of what sustainability risks are and why they are relevant from a business perspective. According to the interviewees, sustainability risks include *"[. . .] two main areas: one, environmental, and two, social justice. Environmental risks involve causing damage, harm to the environment, or nature, or eco-systems [. . .]. Social justice risks involve not treating people, or groups or individuals, in a fair, respectful and non-discriminatory manner"* (academic expert). This also includes business ethics and anti-corruption. Both the academic and industry experts agree that capabilities to effectively manage sustainability risks are decisive for long-term business success: *"sustainability is not something we do because we are so nice people—it's a matter of survival"* (industry expert). This attitude towards the driving forces for sustainability risk management is relatively new: *"in former times, the driving force was to avoid scandals. [. . .] Now, it's about market shares and developing the company"* (industry expert). In addition, investors' increasing interest in companies' sustainability-related capabilities is highlighted as one of the strongest levers for getting senior management attention. An aspect that is considered special for sustainability risks is the significant risk of inaction: *"we are not so familiar with thinking that it is a larger risk not to do and test things than to do them. Traditionally, we think about risks with doing things—not risks with refraining"* (industry expert).

Based on the findings, the following key aspects (KA) were identified:

- **KA1:** Focus on the connection between the company's contribution or counteraction to strategic sustainable development of society (considering both environmental and social issues) and the implications of that for company success.
- **KA2:** Make decision-makers understand that building sustainability-related capabilities ultimately is a matter of company survival.
- **KA3:** Identify and combine levers for different levels and functions within the company to motivate decision-makers to include sustainability aspects in risk management.
- **KA4:** Highlight the risks of inaction in light of the sustainability transition.

4.1.2. Sustainability Risk Context and Criteria

Being able to manage sustainability risks requires organizational capabilities. As exemplified by the following quote, both academic and industry experts consider risk management, if properly introduced, as *"a useful language and a useful tool to make them [companies] think about risks that are not immediately observable or visible in their business context, but that are relevant or will be relevant essentially to*

their bottom line" (academic expert). While traditionally oftentimes dominated by a focus on threats, multiple interviewees stress the importance of considering opportunities, especially because *"when people hear risk management, they usually think 'boring'—but the flip-side, opportunities, means that if you do something smart, you can make a lot of money"* (industry expert). That is a key point because *"changing the language to the opportunities of risk management just changes everything—attitudes, perceptions, biases. Looking at risk management as opportunities alters the whole buy-in process from the Board, through the CEO down to the workers"* (academic expert).

Several interviewees stress the importance of top-down flows of commitment and objectives: "the best companies integrate sustainability from the top, which means integrating sustainability into strategy in a way that is coherent, and you can set measurable goals and targets and once you have that, everything else flows down from that" (industry expert). The CEO specifically plays a key role in showing what sustainability means for the company and because *"if the CEO does not strongly endorse and communicate sustainability risk management, those employees below him/her will often ignore or not have a strong commitment in their efforts"* (academic expert). Such a company understanding of sustainability needs to be created *"with references to and in the context of the larger system sustainability requirements"* (academic expert) in order to avoid overemphasis on, for example, financial sustainability. However, a major challenge with this top-down flow across organizational levels is that *"people talk a lot about it [sustainability risks] and they are very concerned about it, but they don't do anything about it. Typically, because the risks are far too high-level to be practical"* (industry expert). Hence, sustainability risks *"have to be at the level where you can do something about them"* (industry expert), meaning that they must be sufficiently detailed and specific to be helpful in decision-making on different levels. For example, on the operational product development level, it is not enough to identify that there is risk related to climate change. Instead, the risk needs to describe that, for example, because the product consumes fossil fuels in the use phase, which contributes to climate change, there may be a decrease in customer demand in the future.

Whether and to what degree sustainability aspects should be integrated into existing processes and tools or separated is a widely discussed topic in the literature, e.g., in relation to portfolio management [41]. Although sustainability risks can conceptually be separated from other types of risks, based on their source of uncertainty, the experts consistently state that in practice, it is difficult to delimitate sustainability risks from other types of risk, since they are an increasingly integrated part of the enterprise risk universe: *"Some companies got a sustainability risk register, [. . .] but that is kind of pointless, because then you don't integrate it in how you think about strategy and risk"* (industry expert). However, that does not mean that there is no need for explicit sustainability functions, documents, or tools: *"you need both [integrated and separated] actually. For example, we have a sustainability strategy in a separate document, but it is integrated in many other strategies"* (industry expert).

Another organizational success factor mentioned is *"increasing the time frame so that risks with a frame of 20 years that were ignored in the past, are now included"* (industry expert). This is necessary because the time frames for sustainability risks are very variable and because of longer-term risks that may have a low likelihood but a very high severity. The interviewees frequently mentioned short-sightedness as a major challenge, in part due to focus on short-term economic profit.

Based on the findings, the following key aspects were identified:

- **KA5:** Use risk management as a language that practitioners can relate to in order to understand their self-interest for sustainability proactivity.
- **KA6:** Actively include the opportunity side of sustainability risks.
- **KA7:** Establish a CEO lead top-down red thread to identify, assess and manage sustainability risks on the right level of decision-making and the right level of detail.
- **KA8:** Operationalize what sustainability means for the company.
- **KA9:** Understand what conceptually differentiates sustainability risks from other types of risks, but in practice, manage them in an integrated way across all levels of decision-making.
- **KA10:** Include both a short- and long-term time perspective in sustainability risk management.

4.1.3. Sustainability Risk Identification

Risk identification is a crucial step because all risks that are not discovered will not be part of the other steps of the process neither. Identifying sustainability risks comes with challenges, because they are complex and *"get a lot of media coverage but are not very tangible"* (industry expert). On the strategic level, risk identification often starts with *"intelligence studies and materiality assessments to understand the risk universe"* (industry expert), including participation in external forums. Based on the results, *"people are using risk categories as support for identification"* (industry expert), or guiding questions. Some companies also use *"a central team to provoke and provide additional detail both on some of the unique risk of a business unit, but then also to give more insight into what ESG risk means"* (industry expert). However, it is also emphasized that it is not only about understanding and reacting to external trends, such as changes in legislation and customer demands, but also about the strategic vision. Hence, sustainability risks must be identified in relation to both external stakeholders and trends as well as internal stakeholders and strategy.

Some of the companies represented by the interviewees, use scenarios to assess how, for example, sustainability-related legislation might change. In order to be able to be strategic and foresee changes on more and more sustainability-driven markets, backcasting is also necessary to *"analyze where the world in going, because otherwise we will not survive as a company"* (industry expert).

Based on the findings, the following key aspects were identified:

- **KA11:** Use risk categories or guiding questions to support sustainability risk identification.
- **KA12:** Bring in external views and input in sustainability risk identification.
- **KA13:** Identify sustainability risks in relation to both external and internal stakeholder value creation.
- **KA14:** Combine scenario exploration based on forecasting from today, with backcasting based on a vision of a sustainable society in the future.

4.1.4. Sustainability Risk Analysis and Evaluation

Just like other types of risks, sustainability risks are primarily assessed based on likelihood and severity. The difficulty is that sustainability risks are characterized by so-called deep uncertainty [42], making such assessments challenging and imprecise. Further, sustainability includes qualitative aspects, which require a *"value call or judgement for those dimensions that you can't easily quantify in monetary terms [...]*, e.g., *human rights"* (industry expert). To avoid too large subjectivity in the assessment, internal alignment and careful *"calibration of the risk appetite on all levels, all the way back to the strategy"* (industry expert), are necessary, for example by aligning the methodology. Most industry experts state that they use traditional, qualitative risk management tools, such as root-cause analysis, 5 Whys, and risk matrices, also for sustainability risk management, even though with some challenges. Communication and training are pointed out as an important way both for calibrating the risk appetite and for making proper use of tools and methods. This is a common challenge: firstly, *"people internally simply don't got the expertise to—even at a basic level—assess likelihood and severity of sustainability risks"*, and secondly, even if the risks are assessed, *"the chief risk officer or the CFO [Chief Financial Officer] has to then convince the board of the importance of the risks, because they then have to allocate resources to mitigate the risks. They must be able to explain the risk and the impact and likelihood with enough detail and a CFO is not traditionally trained to do this"* (industry expert).

Based on the findings, the following key aspects were identified:

- **KA15:** Balance quantitative and qualitative risk assessment and consider both results in decision-making.
- **KA16:** Define and calibrate the risk appetite, based on company strategy, and align the methodology for sustainability risk assessment across all levels and functions.
- **KA17:** Test both specific tools for sustainability risk management and the integration of a sustainability perspective in existing tools.

- **KA18:** Invest in communication and training for sustainability risk management and consider creating a role like chief risk officer or chief sustainability officer.

4.1.5. Sustainability Risk Treatment

In this step of the risk management process, the company needs to decide on the response to the risks. This is not necessarily different for sustainability risks than other types of risks and the traditional options, e.g., to avoid, transfer, or monitor the risk, may be applied. However, due to the deep uncertainty that comes with sustainability risks, other mitigation strategies should also be considered, for example robust decision-making and resilience strategies [42]. The industrial experts highlight the importance of requirement management in risk treatment: *"By developing requirements, we mitigate the risks that we identified internally and externally"*, to secure the brand, comply with legislation, meet customer needs, etc. Hence, a risk lens is applied in two ways: firstly, to develop the best possible set of requirements to respond to identified risks, and secondly, to ensure that the requirements are fulfilled once they are in place.

While the requirements mostly are cascaded top-down, the risks are escalated bottom-up: "*something in the process is broken if the strategic risks are different from the operational risks. [. . .] Input to the company risks should come bottom-up*" (industry expert), strengthening earlier findings by Schulte and Hallstedt (2018). To determine to what level of decision-making a risk should be escalated, the measure of severity and likelihood is used. However, this may require a difficult aggregation of risks from very specific on the operational level to broader categories on the strategic level. What kind of risk treatment that in the end is selected, usually involves making trade-offs and also depends on the company's risk appetite.

Based on the findings, the following key aspects were identified:

- **KA19:** Use requirements management to treat sustainability risks and apply a risk perspective to ensure that requirements are fulfilled.
- **KA20:** Use the organization's risk appetite to escalate risks to the right level of decision-making, based on their likelihood and severity.

4.1.6. Communication and Consultation

In addition to questions about sustainability aspects in the core steps of the risk management process, the interviewees were asked about other frameworks that they use or know of and that can be used to communicate or get support from in relation to sustainability risk. However, few frameworks were mentioned, e.g., the TCFD. However, *"it's a pity that it only includes climate"* (industry expert) and therefore lacks a holistic systems perspective, which is crucial to avoid sub-optimization. Additionally, it focuses on asset management and does not provide support for establishing a coherent red thread in sustainability risk management that ties together strategic, tactical, and operational levels of decision-making.

Another framework mentioned was the Future-Fit Business Benchmark (FFBB), which provides long-term perspective goals, derived from the sustainability principles of the FSSD, for what any company must achieve in order to call itself sustainable [43]. Using backcasting from the goals, a company can develop a plan for how to move towards the goals in a strategic way. This backcasting perspective is crucial, because it is *"not enough to ask current stakeholders what is on their mind right now—that's not the way to identify the long-term sustainability challenges that could, if not now, become risks in the future"* (industry expert). Even though the FFBB primarily is a sustainability framework, *"risk plays a key role because this is how the need and value of the benchmark is motivated"* (industry expert). A risk perspective could also be applied (i) to prioritize actions towards the achievement of the long-term goals, for example as failing to make process in relation to certain goals may pose more severe threats from a business perspective than in relation to other goals; and (ii) to balance how fast a company should move towards the goals, because there are risks both with being too passive (e.g., reputational

damage, fines, low customer demand), but also with being too proactive (e.g., very high material and manufacturing costs, immature markets).

Based on the findings, the following key aspect was identified:

- **KA21:** Identify and use existing frameworks that can support sustainability risk management.

4.2. Conceptual Approach for Strategic Risk Management within the Sustainability Transition

Based on the key aspects presented above and by combining transition design, strategic sustainable development, and risk management, a conceptual approach for strategic risk management within the sustainability transition was developed, Table 2. Its purpose is to provide support for companies to strategically manage risks that are due to the company's contribution or counteraction to society's transition towards sustainability. Thereby, it aims to help in finding the smart zone between being too passive and too proactive in relation to sustainability aspects.

Table 2. Design and rationale for the development of the conceptual approach.

Conceptual Approach Design	Based on
Starts by envisioning a sustainable future, then assesses the current reality, then explores pathways in between, and then actions are prioritized	ABCD procedure within the FSSD [16]
Uses scenario modeling to explore alternative futures	Transition design, TCFD, KA14
Applies short-, medium-, and long-term time perspectives	KA10
Model scenarios using both backcasting and forecasting and do bridging in between to avoid "sustainability gap" and "reality gap"	KA14, Transition design, [2]
Do the backcasting from a vision that shows what sustainability means for the company while being framed by the eight SPs	KA8, Strategic Sustainable Development, [16]
Uses a layered approach to map scenarios and identify risks on different levels, from macro- to micro level. Thereby, it can also contribute to aligning the company's risk appetite and methodology	KA7, KA16
Identifies the potential threats and opportunities of the identified events in relation to the company's ability to create external and internal stakeholder value based on sustainability risk categories	KA1, KA6, KA13, [6]
Risk identification is supported by risk categories to ease this step and to highlight different levers and the self-benefit of strategic proactivity	KA3, KA5, KA11 [6,28]
Allows for a purely qualitative risk assessment but can also include and benefit from quantitative assessments	KA15
The conceptual approach may be formed into a workshop, which could be used for training and raising understanding and awareness of sustainability risks	KA18
Allows for other existing frameworks to support the conceptual approach, e.g., the FFBB may be used for company visioning and modeling backcasting scenarios	KA21

The conceptual approach consists out of 6 main steps, Figure 5. A fictious case of a large automobile company is used to give examples for each step.

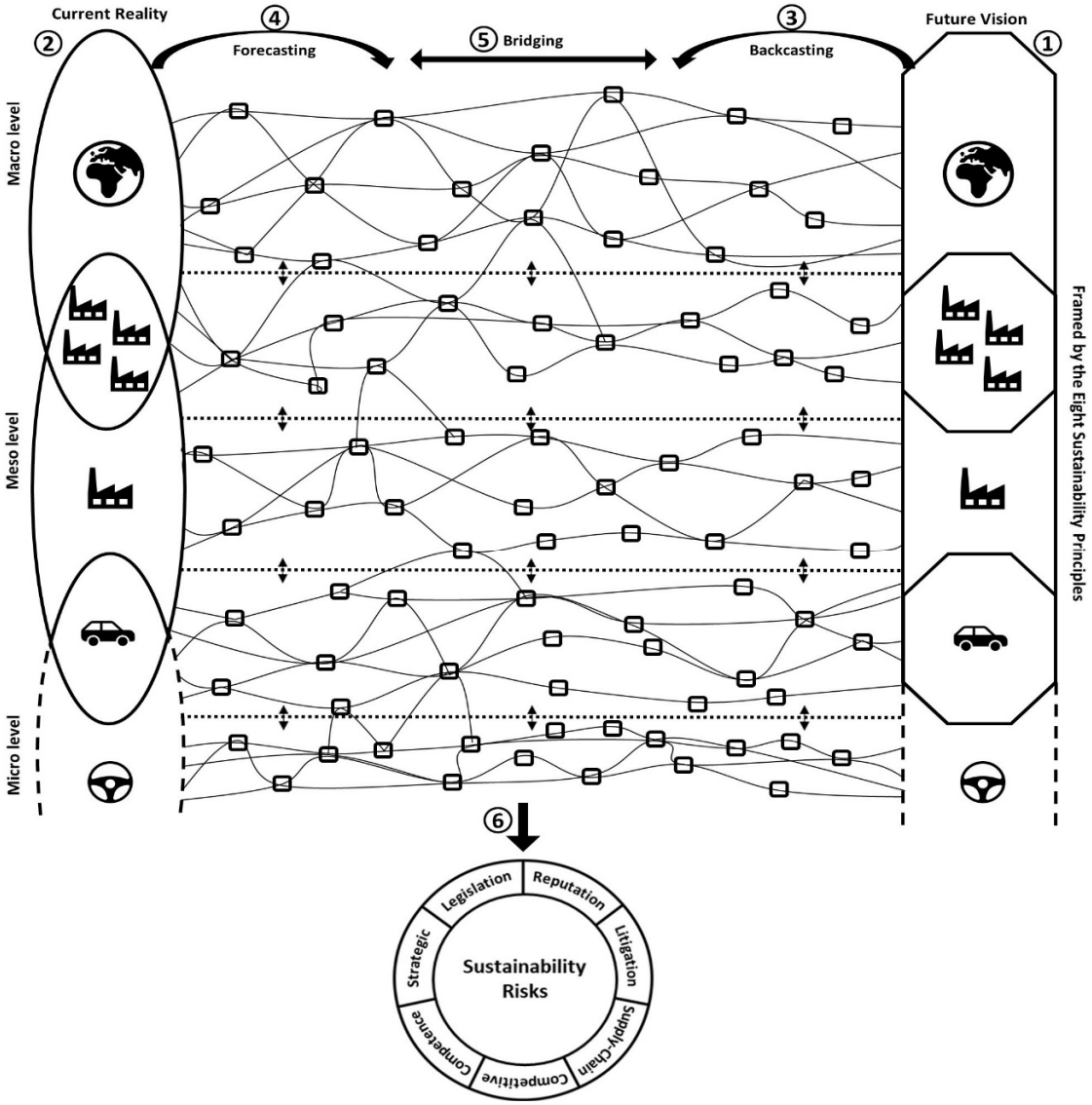

Figure 5. Conceptual approach for strategic risk management within the sustainability transition.

1. Visioning: *"How could a sustainable version of our society/industry/company/product/etc. look like?"* By starting with a vision, a long-term strategic perspective is applied. To ensure that the vision actually is sustainable, the basic sustainability principles are applied as boundary conditions. However, within these boundaries, anything is possible, and the solution space is limited no more than necessary. On the macro level, the SPs might provide enough guidance for backcasting. When zooming in towards the meso- and micro level, the visions should be more elaborated. On the sector level, a vision for a sustainable version of the industry, framed by the SPs, could be used or created if not already existent. On a company level, it would be possible to do backcasting from the Future-Fit Goals. On a product level, a vision of how the value that the product provides could be provided in a sustainable future can be created.

   Example: A macro-level vision could include that there is no use of fossil fuels and close to zero virgin raw material extraction and all materials are instead biomaterials or kept in circular flows within society. Accordingly, zooming in towards the automobile company and its products, the vision could include that mobility is safe and accessible to all people and that all materials in manufacturing are recycled or biomaterials.

2. Current state assessment: *"What are the current sustainability challenges in our society/industry/company/product/etc.?"* An understanding of the current reality is necessary to identify the relevant issues that cause unsustainability in the present and to recognize the discrepancy between the future vision and the present reality. In this step, the SPs can be applied as a lens to scan for hot-spots of unsustainability [44]. Such an assessment can be complemented by looking for current misalignments with other elements of the vision.

   Example: Dependence on fossil energy, freshwater depletion, corruption, discrimination of people based on different grounds, harmful and persistent chemicals in products etc.

3. Backcasting: *"What must happen in order for our society/industry/company/product/etc. to reach its sustainable vision?"* In the third step, potential pathways between the current reality and the envisioned future are explored. To recognize the inherent uncertainty, this is done through scenario modelling, i.e., possible events at different points in time between the present and the future are identified. As described in Section 2.2 and KA14, a strategic perspective is crucial to be able to foresee and anticipate the direction of change on the macro level and to make sure that actions on the micro level lead in the right direction towards full sustainability. The concept therefore applies backcasting from a vision of success. As the sustainability principles are used as boundary conditions for the visions, a "sustainability gap" in the long term is avoided.

   Example: It can be anticipated that there will be increasing costs for virgin raw materials, fossil energy, and landfilling of waste. Norms around cars and their ownership will be different.

4. Forecasting: *"What is likely to happen in the near future in our society/industry/company/product/etc., based on the current situation and existing trends?"* Using backcasting from a sustainable vision requires a long-term perspective. This comes with challenges, especially from a company perspective, because companies also need to plan for the short- and medium-term (KE10). Using backcasting alone can result in a so-called "reality gap" [2]. At the same time, it is possible to explore the short- and medium-term based on the current reality and recent past, informed by a backcasting perspective. The conceptual approach therefore combines backcasting with exploratory forecasting. Companies often do environmental scans and intelligence studies which can provide input to this step.

   Example: Events related to ongoing trends, such as population growth, digitalization, automatization, artificial intelligence, increasing electricity demand, and tougher legislation on greenhouse gas emissions. For the company, events could be the ban of fossil-powered vehicles in cities or tax reforms like bonus-malus.

5. Bridging: *"What could happen in the mid-term that is reasonable based on developments in the short term and sufficient for reaching the sustainable vision in the long-term?"* After having outlined the direction of change in the long-term through backcasting and explored possible scenarios in the short-term through forecasting, it is necessary to create a bridge between these two-time perspectives. This is done by identifying events that could provide links in the mid-term, similar to the identification of aligning pathways in the method presented by Gaziulusoy [2].

   Example: Decentralized renewable energy generation and ownership, radical green tax reforms and internalization or externalities. It could be forbidden to sell fossil-powered cars, at the same time as extensive new infrastructure for alternative technologies could become available.

6. Risk Management: *"What are the implications of our society's/industry's/company's/product's transition towards sustainability for reaching our objectives?"* While steps three and four had the purpose to explore uncertainty, step five is about assessing the effects of that uncertainty on objectives, i.e., risks. As described by Schulte and Hallstedt [6], it is not enough to look at effects on costs. In line with KA13, effects need instead to be assessed in relation to internal and external stakeholder

value creation. That means that the company needs to identify how the previously mapped events, which often have their source in stakeholder actions, could affect the company's/product development project's/etc. ability to create value, e.g., in terms of the ability to execute the company strategy, building a strong brand, getting ahead of competitors, keeping low cost, etc. As highlighted in KA11, risk categories can be used to facilitate this step, as well as goal documents and requirement lists. Once identified, the sustainability risks need to be assessed in terms of their likelihood and severity in order to decide on an appropriate risk response. At this point, KA19 is of particular importance: while risks by definition are identified in relation to objectives, changing or setting new objectives, e.g., strategic goals, detailed product requirements or other, play a key role in treating and responding to the identified risks. For example, goals could be set for phasing out certain substances as a response to identified risks in the form of legislative change, brand reputation, or customer demand.

Example: For the company, the events might come with threats such as increasing costs for raw materials or decreasing demand for vehicles powered by fossil fuel, but also opportunities. For example, the development of advanced value chains for circularity could enable the continued use of some scarce resources, because they could be kept in closed loops. Developing competitive transportation solutions that are not powered by fossil energy can also represent significant opportunities. Once these risks are identified, the company can continue by assessing their likelihood and severity and prioritize responses accordingly. For example, the portfolio of products and technologies can be changed, and sustainability can be integrated in the requirement setting for new development projects, stating that new products, for example, need to be free of certain substances or achieve a certain energy efficiency.

4.3. Limitations and Future Research Directions

Given the purpose of the research and the methodological choices that were taken based on it, the study design also has limitations. Firstly, the sample size limits the validity of the identified key aspects and it cannot be ruled out that there might be additional key aspects, further nuances, for example based on industry sector, or diverging views. However, the interviewees were leading experts in the field and provided extensive and rich input. Additionally, two rounds of coding were performed and multiple techniques for generating meaning from the data were applied. The literature was constantly used to critically reflect on the findings, both in terms of validating previous research, but also in terms of looking for conflicting evidence. Gathering feedback on the results from the interviewees was a way to further verify the outcome. Secondly, the study focused on sustainability risk management in large companies and it is likely that the results only partly are valid for small and medium-sized companies. This was a deliberate choice based on the research purpose and earlier research indicating that sustainability risk management is more widely and more formally performed at large companies. Additional testing is necessary to validate the set of key aspects as well as their applicability in different company contexts. The conceptual approach focused on capturing elements and steps for strategic risk management within the sustainability transition but does not provide detailed support for how to perform the steps in practice.

There is a multitude of ways in which the conceptual approach could be further developed and formed into a practically applicable method: (i) Mapping existing tools and methods that could facilitate the different steps. For example, group model building could be applied for the scenario modelling [45]. Connecting identified events to effects on stakeholder value creation or specific company objectives could be done through sustainability risk trees, similar to Palousis et al. [29]. (ii) Investigating possible formats for how this conceptual approach could be applied in practice. This includes a workshop approach where participants go through the steps of the process, using templates and flip charts, similar to Gaziulusoy et al. [2]. Another option would be to develop a digital tool. Thereby, a company could create extensive, layered scenario maps, as different company functions could add detail from their specific area of expertise, e.g., procurement staff could identify events

related to material availability and costs, or product planners could focus on events related to changing customer demands or technology shifts. Such a digital tool could open opportunities in relation to leveraging the collective competence of employees across the organizational hierarchy; creating both top-down and bottom-up flows of information and risks; and making sustainability risk management an integrated part of company processes and decision-making. (iii) Since requirement setting was highlighted as a key aspect for successful sustainability risk management, future research could study how requirement setting could be used as a risk response to identified sustainability risks. (iv) To fill the need for quantitative assessments in many decision-making contexts, it could be studied how the scenario modelling can be combined with simulation. For example, discrete event simulation or system dynamics could be applied to model aspects like material prices based on the events identified for different scenarios [46]. In more advanced settings, probabilistic and post-probabilistic methods could be used to better include uncertainty in such simulations.

5. Concluding Discussion

Based on interviews with industrial and academic experts, 21 key aspects for successful sustainability risk management in product development companies were identified, covering the core steps of the risk management process described in ISO 31000. The results are well in line with the definition and hypotheses proposed in an earlier study. Feedback provided by the interviewees through a questionnaire indicated the usefulness of the key aspects, especially for decision-making on the strategic level.

Building on the interview results and by bringing together findings from the areas of transition design, strategic sustainable development, and risk management, a conceptual approach for strategic risk management within the sustainability transition was developed. It combines backcasting from a future vision framed by basic principles for sustainability with forecasting from the present. Thereby, possible events and scenarios are explored, which are probable in the short-term given existing trends, and sufficient in the long-term to reach a sustainable state. This scenario modelling can be done on different layers to connect societal transition on the macro level with change that it entails on the meso-, or micro-level. Once potential events are mapped, risks can be identified by studying the implications of the events in terms of threats and opportunities for the company's ability to reach its objectives. The value of this conceptual approach is two-fold: firstly, it connects multiple key concepts in a logical chain that increases the understanding of what exactly sustainability risks are, how they are grounded in the societal transition towards sustainability, how they can both positively and negatively affect product development companies, and what is necessary to become strategic in managing such risks. Secondly, this conceptual approach can be a starting point for the development of practically applicable methods and tools that can support decision-makers in finding the smart zone between being too passive and too proactive in relation to sustainability issues. Potentially, the approach could provide guidance in diverse contexts, from decisions about product portfolios to the selection of materials in product development. Other benefits include (i) learning about strategic sustainable development through backcasting from basic principles; (ii) understanding the company's role within the larger social system; (iii) increased awareness of stakeholders and their needs; and (iv) discovering the connections between the company's contribution or counteraction to society's transition towards strategic sustainable development and business implications in the form of threats and opportunities. However, significant challenges remain, for example in relation to assessing sustainability risks with sufficient precision for decision-making. If overcome, strategic risk management within the sustainability transition could support companies in taking leadership that ensures success both in the short- and long term, for the company and for society at large.

Author Contributions: Conceptualization, J.S., C.V. and S.I.H.; methodology, J.S.; validation, J.S.; formal analysis, J.S.; investigation, J.S.; data curation, J.S.; writing—original draft preparation, J.S.; writing—review and editing, C.V. and S.I.H.; visualization, J.S.; supervision, J.S. and S.I.H.; project administration, J.S. and S.I.H.; funding acquisition, S.I.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research and the APC were funded by the Knowledge Foundation in Sweden, grant number 20180159.

Acknowledgments: Financial support from the Knowledge Foundation in Sweden is gratefully acknowledged. Sincere thanks to the interviewees who participated in the study.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Appendix A. Interview Questions

Note that the questions were adjusted for each interview to fit the role and context of the interviewee.

General Information

1. Is it okay for you that I record the meeting?
2. How long time have you been working at this company?
3. What is your role at the company?
4. Can you tell me about your role at the company and your working tasks?

Theme I: The Concept 'Sustainability Risk Management'

5. In what way do you see that your work connects to risk and/or sustainability?
6. What is your understanding of what sustainability risks are?
7. If and how are they different to other types of risks?
8. Do you treat sustainability risks as a separate risk category or integrate a sustainability perspective into other risk categories? Why?
9. What are the drivers for working with sustainability risk management in your organization?
10. Which three of these drivers would you consider most important? (the interviewee is shown a list of drivers)
11. What do you think are pros and cons with using a risk framing to address sustainability issues in companies?
12. What are your thoughts in relation to this definition? (the definition by Schulte and Hallstedt [6] is presented to the interviewee)

Theme II: Tools and Methods

13. What is your approach for how to work with sustainability risks in practice (identify, assess, manage, communicate)?
    a. How widely is that used?
    b. Is that approach strategic?
14. If and how do you relate to existing initiatives such as the TCFD (Task Force on Climate Related Financial Disclosure) or the COSO framework?
15. How do you use sustainability risk management in your decision-making processes (e.g., when, who, how)?
16. Is the structure for how you work with sustainability risks on different levels of decision making, e.g., ERM, product development, etc., the same? Why and how do they (not) differ?
17. How do you aggregate and cascade such risks?
18. What time perspective do you apply in your risk management processes? Is that the same for sustainability risks?

Theme III: Barriers and Success Factors

19. What is the main strength of your approach for sustainability risk management?
20. What do you think are the main (business) benefits of sustainability risk management in general and with your approach in specific?

21. What limitations and improvement opportunities do you see with your approach?
22. What do you think are the main barriers for organizations to engage in sustainability risk management?
23. In your opinion, what are success factors for making sustainability risk management happen in practice?

Appendix B. Questionnaire Questions

1. What's your name? (Optional)
2. Do you consider yourself mostly as an academic or industrial expert?
3. To what degree do you find the key aspects and other analysis results useful for … (Likert scale: not at all, To low degree, To some degree, To high degree, No opinion or N/A)
    a. Getting a clearer understanding of what sustainability risks are?
    b. Getting insights for how sustainability risks can be identified, assessed, and managed in practice?
4. In which areas do you think the key aspects for sustainability risk management are most applicable and useful? (Please order from most important at the top to least important at the bottom): Product and Service Development, Supply Chain Management, High-Level Strategy, Portfolio Management, Manufacturing/Operations.
5. Are there any key aspects that you do not agree with? In that case, please explain why.
6. Are there any additional key aspects that you find missing? If yes, please explain what that is.
7. To what degree do you have a need for the aspects below when it comes to sustainability risk management? (Likert scale: not at all, To low degree, To some degree, To high degree, No opinion or N/A)
    a. More theory on the concept of sustainability risks.
    b. A clear definition of sustainability risks.
    c. Tools and methods for sustainability risk identification.
    d. Tools and methods for sustainability risk assessment.
    e. Tools and methods for sustainability risk treatment.
    f. Tools and methods for sustainability risk communication.
    g. Including a strategic perspective in sustainability risk management.
8. Do you have any other needs regarding sustainability risk management, not mentioned in the list above? (Optional)
9. Would you be interested to participate in further research on sustainability risk management and allow us to contact you in this regard in the future? This could for example be testing or taking part in the development of a tool. (This is not binding in any way and you can withdraw your potential interest at any point.) (Yes, No, Maybe)
10. Is there anything else you would like to add? (Optional)

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