Sustainability Innovation Cube – A framework to evaluate sustainability of product innovations

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Abstract: Corporations increasingly subscribe to the principles of corporate sustainability, which is generally described as the integration of economic, environmental and social dimensions. Of particular interest are sustainability-oriented product innovations: products are perceived to be a major source of sustainability issues and crucial for tapping into new customer segments and new markets. Yet sustainability-oriented innovations are very risky: Not only is the product's market success uncertain, but also the direction of innovations' sustainability effects, i.e. whether they contribute positively or negatively to sustainability. This paper presents a generic model termed 'Sustainability Innovation Cube' for structuring innovations' sustainability effects and, thus, enabling business to minimize the 'directional risk' of sustainability-oriented innovations. A qualitative expert study reveals the opportunities and challenges related to the developed model. Limitations are discussed and a brief outlook is given.

Keywords: sustainability innovation, product innovation, sustainable development, decision framework, life cycle assessment

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Introduction

Corporations increasingly subscribe to the principles of sustainable development. The concept of sustainability was initially defined by the Brundtland Report in 1987 as a political concept [1]:

> „Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Since then, extensive discussions have unfolded over the question of how such a broad and politically connoted concept can be applied to and operationalized on a business level. Such operationalization is necessary in order to make business actions measurable against their contribution to sustainable development.

From an economic perspective sustainability can be interpreted as a 'constant capital rule' [2]: The capital stock of a company generally consists of economic, natural, and social capital. The concept of a "triple bottom line" identifies only those business activities as sustainable which lead to a retention or increase of a company's overall capital stock. Thus, corporate sustainability is generally described as the integration of economic, environmental and social dimensions into business practise.

If the types of capital are seen in analogy to the generic factors of production – land, labour and capital – sustainability can, on a business level, be interpreted as the maintenance of production factors - and thus as a core concept of doing business. From such a resource based perspective, the concept of sustainability is of fundamental interest for every business and constitutes a basis for profit maximization.

From a more market-based point of view, sustainability offers significant potential for creating competitive advantage. In general, six market potentials can be distinguished [3]: reduction of costs through increase of efficiency, reduction of risks, planning reliability, assurance of legitimacy, attraction of new customer segments and development of new product and business segments. Hence, the concept of sustainability not only promises competitive advantage. It can also be interpreted as a core business concept. A number of empirical studies have identified the positive correlation between sustainability and business success [4].

In the course of the discussion on corporate sustainability, it has been widely acknowledged that *innovation* is of utmost importance for achieving sustainability. Several studies show that the efficiency of current use of resources must increase by a factor of about 10 to 50 in order to achieve sustainability [5]. Such efficiency leaps demand radical new solutions and prove the crucial role of innovation for sustainability. Likewise, there is wide agreement that the challenges of sustainability offer significant potential for innovation and new business opportunities. Two arguments support this view: First, new regulations and laws in social and environmental matters increase the pressure for innovativeness ("regulatory push") [3,6]. Second, sustainability presents a new source of ideas and visions leading to new business opportunities ("vision pull") [7,8].

The positive interdependency of sustainability and innovation is particularly relevant on the product level. While products often lie at the core of sustainability issues, in the form of product differentiation they are also crucial for tapping into new customer

segments and new markets [9,14]. Businesses can therefore be expected to make major efforts in order to develop sustainability innovations. Recent studies show, however, that only a minority of businesses consider sustainability as a source of innovation [10].

The reluctance in advancing sustainability innovations can arguably be attributed to the *high risks* involved in this kind of innovation [11]. These risks include not only the product's market success, but also the direction of innovations' sustainability effects, i.e. whether they contribute positively or negatively to sustainability. For instance, environmental innovations can lead to negative societal impacts as the case of bio fuels demonstrates [12]. On the other hand, conventional innovation projects sometimes result in innovations with positive sustainability effects [13]. In the following, the latter type of risk is termed "directional risk" [14]. Due to the multi-dimensionality of sustainability targets (social, environmental and economic targets) and the dispersion of innovation sustainability effects, the assessment of innovations with respect to sustainability is considered highly complex [15].

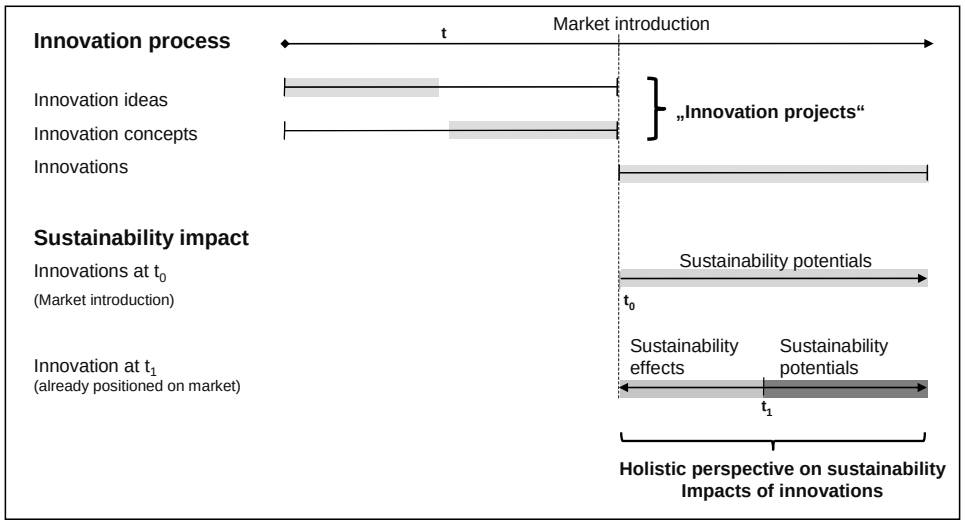
Based on the observation that directional risk is a major barrier for sustainability innovations, we want to address the following research questions: (1) Which are the main constituent dimensions for assessing sustainability effects of product innovations and how can they be integrated into a generic model? (2) How can companies be supported in selecting the optimal method for assessing sustainability effects of product innovations?

The paper is structured as follows: First, we introduce the concept of sustainability-oriented innovations as a means to define the type of innovation this paper is based on. Second, we review the literature with regard to the constituent dimensions to analyze the sustainability effects of product innovations and develop a generic model termed 'Sustainability Innovation Cube' (SIC). Third, we present our results of an empirical validation through semi-structured interviews. We finalize the paper by deriving management implications from the SIC model and outlining its limitations.

The concept of sustainability-oriented product innovations

This paper focuses on product innovations and product innovation projects and their potential effects on sustainability. By product innovations we refer to Hauschildt's definition describing innovations as qualitatively new products which differ significantly from a comparable condition [16]. As a selective distinction of products and services becomes increasingly difficult, we factor innovative product-service-bundles into the definition of product innovation. By product innovation projects we refer to potential product ideas and innovation concepts which are not yet introduced on the market [17]. The focus on product innovation projects is necessary as the assessment of sustainability potentials ideally takes place within the innovation process and thus considers effects occurring already in the development and production phases of product innovation projects. Figure 1 depicts the conceptual differentiations at the basis of this paper.

Figure 1 Conceptual basis



Following the concept of the constant capital rule, it is arguable that sustainability innovations are innovations which maintain or increase the overall capital stock of a company. Hence, Wagner describes ‘sustainability-related innovations’ as better-managed innovations, “[…] where more target criteria are integrated and made mutually compatible.“ [18].

Yet a definition which refers to the firm’s capital stock leads to severe issues in practice: choosing the net effect of an innovation with regard to the overall capital stock as the constitutional attribute requires methods for aggregating and substituting the innovations’ effects on the different types of capital. Aggregating economic, ecological and social effects inevitably leads to trade-offs and is limited due to current methodological constraints [19,20]. Furthermore, such a balancing process always includes ethical as well as cultural considerations which lead to different conclusions in different contexts [21]. Objective and specific “labelling” of innovations as being sustainable can therefore only be achieved within a collective and social discourse.

Being aware of these issues we introduce the concept of sustainability-oriented innovations (SOI). This concept builds on Wagner and considers SOI not as a qualitatively new form of innovation, but as innovations with a positive net effect on the overall capital stock. The concept takes on the notion that the objective and absolute evaluation of an innovation’s sustainability effects is currently unfeasible. Therefore, we define sustainability-oriented innovations as innovations which are *individually* perceived as adding positive net value to the overall firm’s capital stock. However, such positive value must always be related to a comparable condition. In this manner, the concept of ‘sustainability-oriented innovations’ expresses only an individual declaration of intent. A priori, the direction of the actual effects of an innovation to sustainable development is unknown. The risk of such an innovation is the previously introduced ‘directional risk’.

Due to common market risks and the directional risk of sustainability-oriented innovations, SOI are considered highly risky. Yet, as described above, these innovations are of high interest to businesses and society. Therefore, generic methods are needed to reduce the directional risk of sustainability-oriented innovations. In particular, methods to

assess innovations' sustainability effects are attractive to companies when spurring the development of sustainability-oriented innovations. These methods must tackle two subsequent steps: First, they have to define focal areas and issues where potential sustainability effects are analysed [22,23], subsequently called 'search focus'. Second, they have to identify and quantify the relevant sustainability effects. While many methods are able to identify and quantify sustainability effects of products with regard to specific sustainability-related issues (e.g. social audits, eco-efficiency indicators), they largely omit the first step of defining the appropriate search focus.

A company's decision of defining the best possible search focus can be interpreted as a *cost-benefit-consideration*: A broader defined search focus reduces the risk of direction but increases search costs and vice versa. In general, current assessment methods have a pre-defined search focus, in which they identify and quantify sustainability effects. Accordingly, these methods do not enable businesses to perform cost-benefit-considerations. As a result, current practice does not enable firms to select the most appropriate method for sustainability assessment. A 'meta-method' is needed matching the firm's risk awareness and its defined search focus with existing assessment methods (and their pre-defined search focus) in order to direct the firm to the most appropriate method.

Sustainability Innovation Cube – a generic model

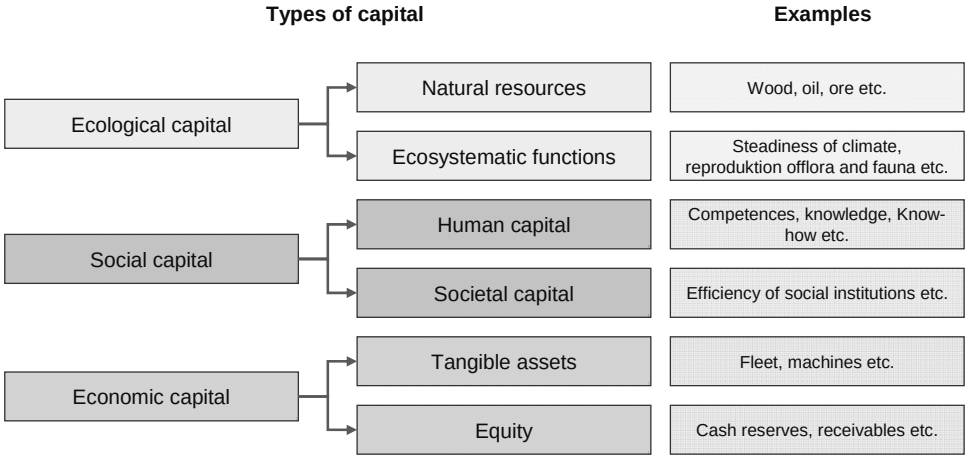
Generic dimensions are essential for assessing and structuring innovations' sustainability effects. On the basis of the existing literature we identified three constitutional dimensions for assessing sustainability effects of sustainability-oriented innovations: the *target dimension*, the *product life cycle dimension,* and the *need dimension*.

The target dimension

This dimension analyzes innovations' effects according to their impacts on sustainability targets. In doing so, this approach requires a sufficient operationalization of sustainability. Here, we use the triple bottom line concept [24]. Although severely criticized, this concept received major acceptance among business executives in the course of the discussion on „Corporate Social Responsibility" making it a widespread concept [25]. As we aim at developing a generic model which is highly communicable and accessible for business executives, we selected this concept as the most appropriate for our purpose.

With reference to the triple line concept and the constant capital rule, innovations' effects must be assessed according to their impact on the different types of capital, namely economic, ecological and social capital [26]. Figure 2 illustrates these different types of capital.

Figure 2 Overview on different types of capital of a firm



Source: Interpreneurship, 2005, Fichter, K.

In the following, we focus on social and ecological types of capital because previous decades of research on the *economic capital* already suggest a mature state. *Ecological capital* is affected by the level of consumption of renewable and non-renewable resources and the influences on the eco system [15,26].

At this point the special role of *social capital* should be highlighted. Social capital can be seen as supportive capital which is established in relations to stakeholders inside and outside the company [27]. Therefore, the assessment of innovations' effects on social capital demands a stakeholder perspective and the identification of important stakeholder groups [28]. It has to be underlined that in many cases the effects on the societal capital appear subsequently. Nevertheless, sustainability effects frequently arise in this area and have a major impact on the directional risk of SOI.

Social effects are considered to be difficult to assess on a product level. Therefore, an organisation is often analysed in its entirety [29]. Still, recent approaches try to address social sustainability on a product level [30,31].

To summarize, we distinguish three assessment criteria of innovations' effects within the target dimension: economic effects, ecological effects and social effects.

The life cycle dimension

As innovations' sustainability effects are widely spread over time and space [15], the target dimension is not enough to provide an assessment structure for sustainability effects. Thus, researchers identify different phases in which sustainability effects may occur. Traditionally, researchers analysed organisational aspects including the *production processes* and the related occupational safety, health and environmental aspects [32,33]. Also, *supply chain effects* became an area of interest [34]. The holistic perspective covering the complete life cycle further includes sustainability effects in the phase of *usage* and *end-of-life* [29]. This is important as sustainability effects frequently occur during these phases and heavily influence the sustainability impact of innovations [35]. This approach implies, however, that customer behaviour and usage behaviour must be

considered in the sustainability assessment (we will address this question in the subsequent section). The detailed life-cycle covers: extraction of raw materials, design and production, packaging and distribution, use and maintenance, reuse and recycling, incineration and disposal [36]. Simultaneous assessment of these areas is referred to as life-cycle assessment [23,37] which is very common in business [38]. This 'life cycle' refers to the ecological life cycle ("from cradle to grave") [39] in contrast to the market-oriented life cycle [40].

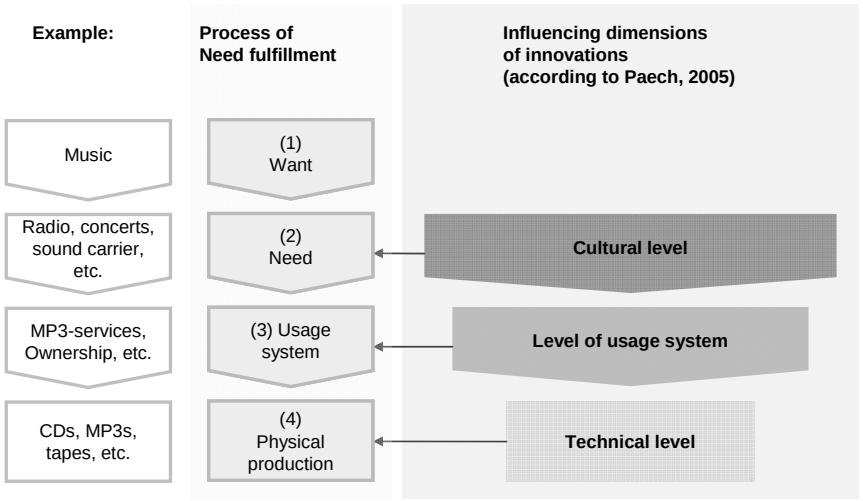
The life cycle perspective is necessary as nowadays resource and material flows are considered as major environmental issues. From an overall perspective three main life cycle phases emerge: production and logistics, usage, and end-of-life.

The need dimension

Today's need structures and lifestyles are deemed one of the major causes for sustainability issues [41]. Hence, the impact of an innovation on consumption patterns significantly affects the innovations' sustainability potential. Paech describes a generic process in four major steps of how needs are fulfilled [42]: Starting with anthropological wants concrete functions or needs emerge. These needs are highly dependent on cultural influences and, hence, manipulable by innovations. These needs are satisfied with physical goods through routines or practices which Peach describes as usage systems.

Based on this process of needs fulfilment, Paech differentiates between three levels on which innovations may influence the process. On the *technical level*, innovations can demonstrate new ways of satisfying needs through new physical products (e.g. iPods). On the *level of usage patterns*, innovations can describe new routines of how needs are fulfilled (e.g. selling solutions instead of selling products). On the *cultural level*, innovations can create new needs or change the design of current needs (e.g. playing music instead of just listening to it). Figure 3 illustrates the different levels.

Figure 3 The need fulfilment process according to Peach



Source: Nachhaltigkeit als marktliche und kulturelle Herausforderung, 2005, Paech, N.

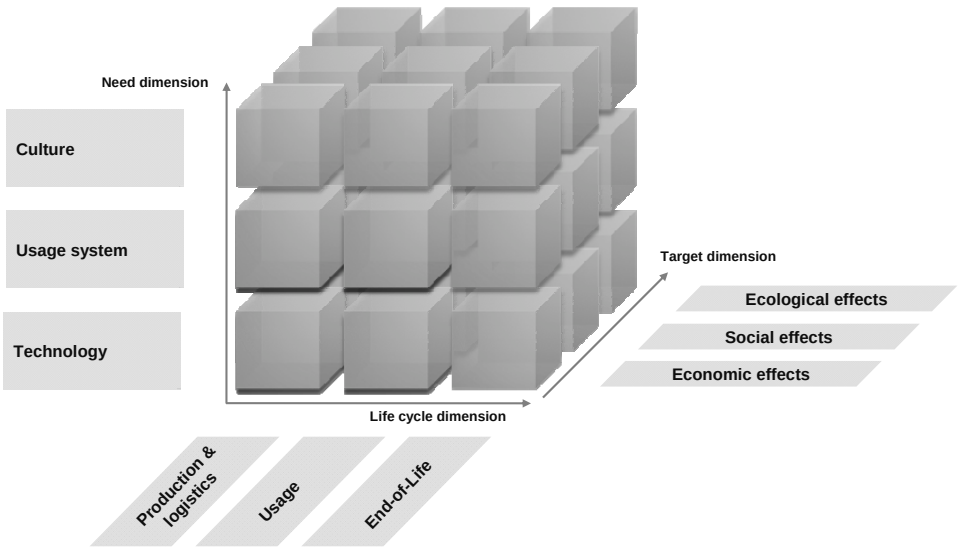
We consider the cultural dimension as the most controversial dimension, as from a corporate perspective changing consumer needs may challenge existing business models [43].

In summary, the process of need fulfilment makes clear that innovations may impact the process on different levels and thus have different sustainability effects. Accordingly, we identified the need dimension as a third assessment dimension consisting of three criteria: the technical level, the level of usage system and the cultural level.

The Sustainability Innovation Cube (SIC)

Based on these three constitutional dimensions, we developed a generic model termed 'Sustainability Innovation Cube' (SIC), which displays all potential sustainability effects. The SIC unfolds into 27 individual areas which indicate where sustainability potentials may arise. These sustainability areas can be regarded as targets to be addressed by innovation management. Figure 4 depicts the sustainability areas.

Figure 4 The Sustainability Innovation Cube



From a business perspective, the SIC illustrates 27 different areas in which sustainability effects may occur. In order to minimize the directional risk of an innovation, ideally all 27 areas are analyzed. However, each additional sustainability area to be assessed also increases the assessment costs. Hence, companies face a cost-benefit-analysis when defining the appropriate search focus, i.e. when they select which of the 27 areas should be assessed. By transparently illustrating all major sustainability areas, the SIC model supports companies in pursuing such cost-benefit-considerations.

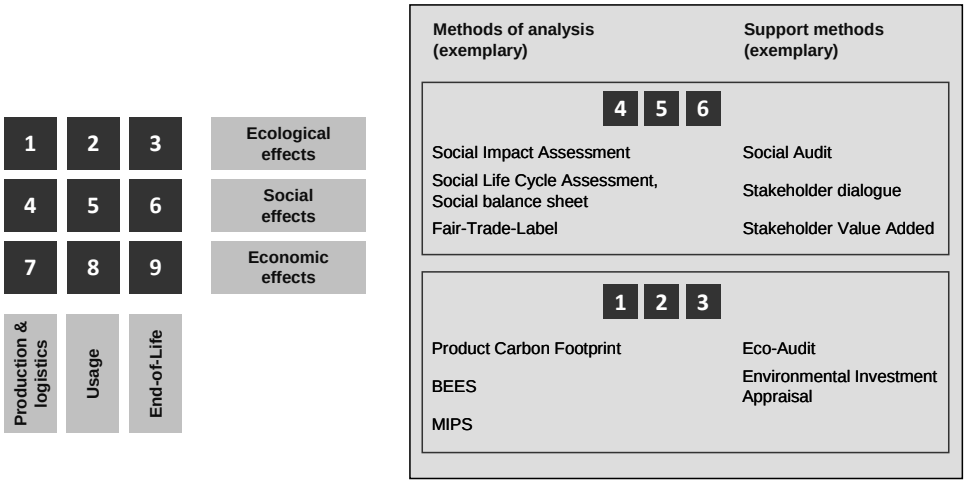
The SIC model, however, does not yet enable companies to identify and quantify sustainability effects in each of the 27 sustainability areas. The above SIC model does not define criteria for identifying sustainability effects in each of the sustainability areas. The selection of such criteria is highly dependent on the innovation to assess, the company

that pursues such an analysis, and the chosen assessment method [44]. Due to these factors, the selection of sustainability criteria is highly diverse and needs to be specifically adapted to each assessment situation. By not defining specific criteria, the SIC is a generic model which is applicable to all kind of innovations, companies, and situations.

Nevertheless, the quantification of innovations' sustainability effects is essential if such assessments shall provide a basis for decision-making within innovation management (i.e. which innovation project should be continued) [30]. In a second step, we therefore assigned current methods for product assessment to the 27 areas of the SIC model. This is necessary as current assessment methods diverge significantly in their internally pre-defined search focus. While some methods, for instance, only take into account environmental effects (e.g. ecological balance sheet), other methods focus exclusively on the life cycle phase of production (e.g. Sustainable Supply Chain Management).

In total, we assigned 71 existing methods to the 27 sustainability areas of the SIC model. We thereby distinguish two groups of methods: While 'support methods' enable companies to assess sustainability effects ex ante, i.e. over the course of the innovation process, 'methods for analysis' focus on established products on the market and assess their sustainability impacts ex post. The assignment of methods is depicted exemplarily in Figure 5.

Figure 5 Assignment of sustainability assessment methods to SIC areas (exemplary)



Notes: This is a two-dimensional slice of the SIC model leaving aside the need dimension. An exhaustive list is given in the Appendix (Table 1 and Table 2).

Therewith, the SIC model follows the two subsequent steps mentioned above: By depicting all major sustainability effects, the SIC model supports companies in defining their search focus. By assigning current assessment methods to the individual sustainability areas within the SIC model, indications for appropriate methods and tools are provided to identify and quantify the relevant sustainability effects. The SIC model

itself is therefore not a sustainability assessment method but rather a meta method which guides companies to the right choice of assessment tools.

Research methodology

So far, this paper presented a normative research approach to determine the constituent dimensions for assessing innovations' sustainability effects. Starting from a systematic literature review, we identified the constituent dimensions of assessing sustainability effects of product innovations and developed the SIC model. In a second step, we conducted qualitative research using semi-structured interviews to validate the SIC model and its dimensions [45]. As previous research in the area of sustainability suggests to address high-level corporate officers to get the most accurate information [46],we interviewed 12 high-level sustainability experts from leading organisations in Germany in the second half of 2008. These experts belong to two groups: corporate experts (8 executives) and research experts (4 senior researchers). These organisations reflect a variety of different industry sectors (e.g. logistics, finance, consulting, etc.). The diverse selection of interview partners guarantees a holistic perspective on the topic and uses very different experiences and opinions in the field of sustainability. The interviews were recorded, transcribed and analysed with qualitative data analysis [47].

Findings

During the interviews we received vast feedback on the SIC model and its potential implementation in innovation management. We recorded both broad agreement and controversial opinions on the constituent dimensions of the SIC model, which we would like to outline in the following.

The target dimension

We experienced broad agreement on the triple bottom line concept among researchers and business executives, which underlines the high diffusion and acceptance of this concept. However, applying this concept on a product level we observed highly controversial views on 'sustainability innovations'. Some interviewees claimed that truly sustainability innovations must not create negative impacts to any of the three bottom lines:

> "Only regional products can be regarded as truly sustainable. Other products cause transportation efforts and therefore cannot be regarded as sustainable."

Others, however, criticised this narrow definition of sustainability as too theoretical:

> "Innovations can never create positive sustainability effects on all target dimensions. Such an innovation would be bonanza."

The importance of considering more than just one of the triple lines when talking about sustainability innovations was highlighted by several interviewees:

> "Considering the definition of innovation [i.e. that the term innovation implies success on the market], one could argue that every innovation can be regarded as sustainable."

These viewpoints underline the difficulties when trying to define sustainability innovations. The definitions of SOI brought forward in the interviews support our argumentation that balancing processes on the varying effects to the triple bottom lines lie at the core of defining sustainability innovations. The proposed concept of sustainability-oriented innovations described above builds on that notion. We further noticed that the assignment of social effects on a product level was perceived as being particularly difficult. This confirms the methodical difficulties of assessing social impacts of products [31].

The life cycle dimension

On this dimension we observed broad acceptance among corporate and research experts. It was highlighted that a life cycle assessment implies a more holistic approach to sustainability:

> "The integration of a life cycle consideration is beneficial when outlining subsequent sustainability effects, e.g. during the usage of products. These effects are still hardly considered."

This observation adds to the fact that life cycle considerations are commonly known and integrated in numerous business concepts and theoretical concepts.

The need dimension

In comparison to current methods, the SIC model integrates the impact of innovations on the process of need fulfilment. Research experts perceived this perspective as crucial given that current need structures are considered a driving factor of sustainability problems. However, business executives disagreed on whether or not this dimension offers significant business opportunities. Some questioned whether the need dimension within the SIC may offer significant business opportunities:

> "The need dimension does not reflect any source of differentiation for businesses."

On the other hand, others outlined the 'creative destruction' of current need structures as major business opportunity:

> "Companies need to change current need structures to make sustainable products being perceived as 'cool'. This would have a major impact on sustainability and offers great potential for businesses."

These notions underline the different perspectives on business opportunities through sustainable products. As these markets are nascent, the estimations of market growth and market size vary significantly and may contribute to the reluctance of companies in spurring SOI.

Implementation in innovation management

All interviewees outlined the advantage of the SIC model in providing an orientation framework for sustainability effects. This might be particularly helpful when employees need to be introduced or sensitized to the concept of sustainability. Corporate experts initially criticized the lack of possibilities to quantify sustainability effects within the

sustainability areas, but acknowledged later on the SICs role as a meta method. These observations underline two facts: First, businesses seek accurate information on innovations' sustainability effects as a basis for decision-making. Second, large companies may already build up their toolbox of assessment methods and may not necessarily take advantage of the SIC as a meta method. Small and medium sized enterprises (SME), on the contrary, might not have enough resources to engage in the field of sustainability assessment. Here, the SIC model as a meta method could significantly support companies in providing guidelines to appropriate assessment methods. Yet the particular value of the SIC model for SMEs extends the scope of this paper and is a suitable subject to further research.

To summarize, the SIC model gained significant support in illustrating all major sustainability effects of product innovations. As an orientation framework and introduction to the field of sustainability, it adds value to innovation management. Beyond that, further implementation into innovation management would be subject to further development of the model.

Practical implications for innovation management

Businesses with an interest in driving SOI should try to eliminate negative and encourage positive sustainability effects in each of the 27 sustainability areas. The structure of the SIC model and the discussion on the concept of sustainability-oriented innovations proposed several implications for innovation management. We will discuss them one by one in the following.

Integration of sustainability criteria

The highest potential of shaping and designing innovations lies in the early stages of the innovation process. This especially applies to the sustainability potential of innovations. While the SIC model suggests possible target areas for SOI, this alone would not positively affect the creation of SOI. Rather, sustainability criteria must be integrated into the innovation process to guide the development and creation of innovations and assure that sustainability potentials are taken into consideration along the way. Our interviewees confirmed that companies like 3M or Henkel already use such sustainability criteria within their innovation management. The generation of sustainability-related information in the very early stages of the innovation process will pose challenges to innovation management, as the innovation idea is comparatively undefined. However, the earlier such information is considered and integrated in the innovation development, the better the innovation can be shaped towards a positive sustainability impact (this does not neglect the fact that innovations achieved without systematic sustainability assessment sometimes also lead to sustainability-related innovations [13]).

Sensitization in the context of sustainability

The concept of SOI highlights that the evaluation of sustainability-related innovations is highly distinct on an individual basis and therefore diverse. Sensitising those decision makers involved in the innovation process for sustainability issues is therefore crucial to the creation of SOI. The more decision-makers are sensitised, the better they can identify

and estimate sustainability potentials and varying views of important stakeholder groups. Hence, sensitisation of decision-makers may lead to a reduction of directional risks of SOI.

Integration of stakeholders

Currently stakeholders are very loosely integrated in the innovation process [28]. Yet, in the context of sustainability stakeholder integration offers major advantages for innovation management [10]: First, social effects of innovations can most accurately be assessed by integrating the affected stakeholders directly into the assessment process. Second, the integration of stakeholders reduces the risk of being the sole accused if subsequently sustainability problems arise. Third, through the integration of stakeholders' complementary implicit knowledge into the innovation process may lead to new innovations.

Integration of usage patterns

Sustainability effects frequently arise in the usage phase. Usage patterns of products have significant influence on innovations' sustainability potential; therefore, they should be taken into account as early as during the innovation process. Hence, new concepts of integrating users into the innovation process (e.g. open innovation, mass customization, Living Labs, etc.) gain significant importance in the course of sustainability.

Need creation as challenge for innovation management

The integration of the need dimension into the SIC model demonstrates that technical solutions might not suffice to drive sustainability-oriented innovations. Innovation management will be more and more challenged to create and design new sustainable needs and change current lifestyles [48]. New co-operations and partnerships will gain significant importance [49]. Hence, a sole technological understanding of innovation management might not be sufficient for the development of SOI. However, validation of the SIC model proved that this perspective is in strong contrast to current understandings. Further case studies and best practices are beneficial to prove the potential of considering need creation as an innovation challenge.

To summarize, the development of SOI may pose major challenges to innovation management. A pure technical, internal understanding must give way to a more open, interactive understanding of innovation management in order to fully exploit the potentials that sustainability-oriented innovations have to offer.

Limitations and further research

The SIC model is limited in several ways. First, the purpose of this work was to develop a generic framework, which illustrates all major sustainability effects of product innovations. Although the sustainability areas of the SIC models may serve as target dimensions within innovation management, it remains unclear how these dimensions can be incorporated into the innovation process. In order to better apply the SIC to business practice further research could address how to integrate the model into a process model.

This also applies to the process of defining an appropriate search focus for which the SIC might serve as an ideal basis.

Second, we interviewed sustainability experts from leading organizations within our qualitative study as these organizations are highly engaged in corporate sustainability and SOI. However, the SIC model may also add value to SME by supporting their efforts in driving corporate sustainability. This particularly applies to the SIC model serving as a meta method (as described above). The implementation of the SIC model in SMEs may thus be an interesting field for further research.

Third, the focus of this work lies in the assessment of product innovations as products offer major business opportunities as well as sustainability potentials. However, immaterial products and services promise to be interesting for further research as these decouple economic growth from material flows. It could be subject to further research whether some of the constituent dimensions identified in this work also apply to immaterial products and services.

Conclusion

The paper adds to the growing body of literature on sustainability innovation and on methods and tools for the assessment of product sustainability. We started this paper by arguing that sustainable product innovations are of high interest for businesses. By introducing the concept of sustainability-oriented innovations we highlighted the fact that objective evaluation methods for defining sustainability-related innovations do currently not exist due to the multidimensionality of sustainability. Instead, SOI are innovations which are individually perceived as adding positive value to sustainable development.

We introduced the constituent dimensions to assess sustainability effects of sustainability-oriented innovations. We further presented a generic model termed ‘Sustainability Innovation Cube’ illustrating all major sustainability effects of product innovations.

The SIC offers an orientation framework for sustainability effects and enables business decision-makers to define their appropriate search focus for sustainability effects. Based on the search focus which a firm seeks to analyze, indications for appropriate methods and tools are provided. In this regard, the SIC model does not constitute a sustainability assessment method but rather a meta method which guides companies to the appropriate assessment method. Limitations of the model and areas of further research also have been addressed. By depicting all major sustainability effects of product innovations, the SIC reduces the directional risk for product innovations and enables companies to drive SOI.

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Appendix

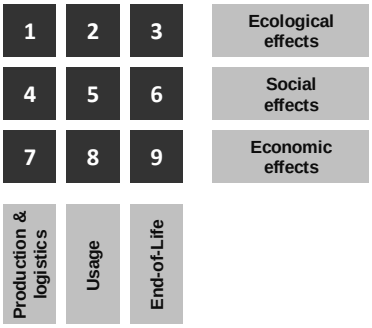

Table 1 Assignment of sustainability assessment methods to SIC sustainability areas (This overview does not claim for completeness)

Area	*Methods of analysis*	*Support methods*
4		Social Accountability SA 8000
		OHSAS 18001
		Corporate Social Accounting
		Social checklist
		Community Advisory Panel
		Cost-Risk-Dialogue
1	Environmetal information system	EMAS
		ISO 14001
		Environmental Budgeting
		Eco-checklist
		Green Supply Chain Management
1,7	Life Cycle Management	
1,4,7		Sustainability management systems
		Sigma Guidelines
		Corporate Social Responsibility (CSR)
		Sustainable Supply Chain Management
		AT Kearney Sustainability Card
4,5,6	Social Impact Assessment	Social Auditing
	Social Life Cycle Assessment	Stakeholder Dialogue
	Fair-Label	Stakeholder Value Added
	Social balance sheet	

Table continues…

2,5,8		Living Labs
		Integrated Roadmapping
		Lead User Method
		Toolkits
		User Communities
1,2,3	Eco-Auditing	Ecological footprint
	Environmental Investment Appraisal	Environmental Impact Assessment
		Environmental Risk Assessment
		Life Cycle Assessment, Ecological balance sheet
		Eco Compass
		Eco-Label
		Integrative Product Policy (IPP)
		Resource productivity
		Eco-efficiency
		Product Carbon Footprint
		BEES
		MIPS
1-3, 7-9	Eco-efficiency Analysis	
7,8,9	Traditional Innovation Management	
	Life Cycle Costing	

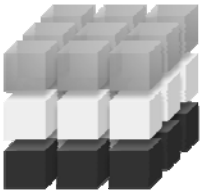

Table 2 Assignment of sustainability assessment methods to SIC layers, along need dimension (This overview does not claim for completeness)

Layer	*Methods of analysis*
Top	Eco-Restructuring
	Sustainability Marketing
Middle	Open Innovation
	R&D cooperations
	Interpreneurship
	Sustainability Marketing
	Sustainability-oriented innovation networks
Bottom	Traditional Innovation Management