SUSTAINABILITY-ORIENTED INNOVATION

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Synonyms

Definition

Sustainability-oriented innovation (SOI): the commercial introduction of a new (or improved) product (service), product-service system, or pure service which – based on a traceable (qualitative or quantitative) comparative analysis – leads to environmental and (or) social benefits over the prior version’s physical life-cycle (“from cradle to grave”).

Introduction

The importance of business practices to solve present sustainability issues, such as climate change, environmental degradation and social inequalities has been emphasized in literature for quite some time (Elkington, 1992; Hart & Prahalad 2002; Yunus & Weber 2007; Roth 2009; Porter & Kramer 2011). From a business perspective the areas of corporate sustainability, corporate responsibility and corporate social responsibility (CSR) all seek to address these issues by transcending the core responsibilities of businesses (i.e. to make profits) to non-economic (or better pre-economic) aspects such as ecological and social responsibilities. This notion is frequently addressed as the “Triple Bottom Line” (TBL) (Elkington 1992).

Whilst the last decades of research in sustainability (and particularly the environmental dimension) has focused on improvements on the levels of processes (e.g. eco-efficient production; health and safety) and the organization (e.g. environmental management systems; codes of conduct), scholars have lately emphasized putting sustainability at the core of a corporation’s value creation activities (Louche et al. 2010) and thus products and services (Hart 1997; Maxwell & Van der Vorst 2003). Consequently, innovations are perceived to
play a paramount role in the area of corporate sustainability (Hart et al. 2003; Hockerts & Morsing 2008) and, going even further, the business case of sustainability-oriented innovation activities is increasingly acknowledged (Hockerts & Wüstenhagen 2010). In the present article, it is thus understood that sustainable development can be advanced through market mechanisms, specifically, through the diffusion of more sustainable product (or service) offerings.

In recent years, research in the area of sustainability-oriented innovation (SOI) has increasingly emerged and addressed the theme from different vantage points: Research on eco-innovations (Rennings 2000) and social innovation (Deiglmeier & Miller 2008) focus on one specific dimension of SOI. It is often established organizations – both large scale corporations as well as small and medium-sized enterprises – in which SOI is considered an important concept for the transformation of an organization’s product offerings. In contrast, the concepts of ecopreneurship, social entrepreneurship and sustainable entrepreneurship highlight the importance of new firms and start-ups to spur sustainable development through Schumpeter’s mechanisms of “creative destruction” (Schaltegger 2002; Yunus & Jolis 2003; Hall et al. 2010; Schaltegger & Wagner, 2011). In a broad sense as applied here, all these innovation endeavours – independent of the actual firm specifics – can be considered SOI.

**Key Issues**

In principle, product innovation is related to great uncertainty with regard to market success, as it is often difficult to anticipate the exact consumer needs, consumer behaviour, as well as future economic conditions (Cooper 2001). SOI incorporates even higher risks as additional environmental and social dimensions have to be considered (Dyllick & Hockerts 2002; Fichter & Paech 2004; Paech 2007; Hansen et al. 2009). According to Paech et al. (2007) SOI is linked to ‘directional risks’, as the direction of (environmental and social) sustainability impacts of innovations are highly uncertain, particularly in the long term. For example, bio fuels were regarded as beneficial for the environment, just until negative side-effects were discovered (e.g. monocultures and loss of biodiversity; impact on food prices), which actually undermine the initial positive impact and put bio fuels into question. In this regard, the term ‘sustainability-oriented innovation’ (SOI) emphasizes that sustainability is not an end point but rather a (normative) direction which is linked to (directional) risks (cf. Fichter & Paech 2004; Paech 2007; Wagner & Llerena 2008; Hansen et al., 2009).

SOI can be further analysed regarding (innovation) outcomes and (innovation) processes (Crossan & Apaydin 2010). Whilst outcomes look more at the resulting characteristics of innovation, innovation processes determine how the innovation is developed. Both notions will be addressed in more detail in the following.

**Characteristics of outcomes of SOI**

Two major dimensions can be considered for specifying the outcomes of SOI: the target dimension and the life-cycle dimension (Hansen et al. 2009).

The target dimension directly relates to corporate sustainability as the triple bottom line [see Triple Bottom Line], a term used to express the expansion from a narrow financial bottom-line (i.e. economic profits) to a wider recognition of financial, environmental and social bottom lines. Whilst in the past innovation management has been primarily focused on the economic (i.e. market) success of products and services, in the context of sustainability, innovation also needs to take social and environmental spheres into account.

It should be emphasized that the three spheres (economic, social, and ecological) have strong interrelations. It is thus of primary importance to not only optimize one single component in an isolated way, but take into account subsequent impacts on other systems as well. Generally, the economic is part of a social system, which in turn is embedded in the ecological system. Consequently, as there is only one finite planet earth, the
ecological system ultimately constraints the societal and economic spheres. On a more pragmatic level, there are various links (both positive and negative) between these three spheres. First, social and environmental aspects are often linked to economic aspects. The most popular link is probably the concept of eco-efficiency which is able to advance economic and environmental aspects simultaneously. Second, there are also links between social and environmental spheres. Consider again the case of bio fuels: Although a short hype around its potential to fuel cars with renewable resources emerged, the enthusiasm for bio fuels was rather short-lived as the necessary cultivation of oil-bearing trees also implicated a displacement of food crops and thus negative side-effects to the local population (e.g. advances of food prices). Therefore, from a holistic point of view (which the concept of SOI aims to be), it remains questionable whether bio fuels per-se can be considered a SOI. An example from the food industry may demonstrate how indeed social and environmental performance can be achieved simultaneously. The Austrian chocolate manufacturer Zotter has experienced double digit growth rates for several consecutive years with the production and sales of socially and environmentally-benign chocolate (Khaire et al. 2010). The company only uses cacao beans from certified organic agriculture and purchase them through fair trade schemes.

Besides the target dimension, the life-cycle dimension is key to define the intended outcomes of SOI. Traditionally, the development of products and services has focused more narrowly on the direct customer value and thus aimed at optimizing a product’s core functional or technical characteristics (e.g. a powerful car engine). SOI also addresses these core attributes of the product (e.g. through product safety, energy efficiency, durability), but goes beyond this notion. As the aforementioned example of the chocolate producer approach to fair wages in the supply chain has demonstrated, the management of SOI needs to transcend the product’s use phase to focus on the entire physical life-cycle [see Life Cycle Analysis; Sustainable Value Chain] from raw materials to end-of-life (“from cradle to grave”). In the context of sustainability, considering the entire value chain is vital for innovation in order to identify major sustainability problems and tackle those problems at its origin (Maxwell & Van der Vorst 2003).

With regards to SOI, five life-cycle phases are important, where major sustainability effects emerge – supply chain, production, packaging/distribution, use and end-of-life (see Table 1):

- First, supply chain covers all raw materials as well as pre-manufactured components, parts, or modules sourced from third-party suppliers [see Sustainable Supply Chain]. This includes not only direct (first-tier) suppliers but also (n-tier) suppliers further upstream. Environmental and social risks (e.g. child work, ethical and environmental standards, legal standards, bribery etc.) are often inherently linked to sourcing from other countries, particularly from developing countries. Focal companies, in their endeavour to introduce more sustainable practices in the supply chain, often innovate by introducing stricter social and environmental procurement policies and related process innovations such as sustainability-oriented supplier selection, evaluation and development.

- Second, production covers the proper tasks of the company in manufacturing or integrating the final good. Sustainability-related issues that may emerge at this phase are, for instance, eco-efficient resource and energy use, waste handling, use of renewable energy, use of eco-friendly materials and occupational health & safety issues, among others.

- Third, packaging/distribution covers the packaging of products and the efficient distribution of the final goods. Life-cycle analysis of individual packaging options are an important decision criterion for the selection of the good’s packaging.

- Fourth, the use phase addresses sustainability effects during the use of products or services. Although the use of products and services lies in the responsibility of the customer and is, hence, difficult to control, the company has the power to make design decisions that consequently define the characteristics of the usage of product/service (e.g. product-service-bundles). For example, by bundling electric cars with renewable energy contracts, carbon-free driving can more likely be
guaranteed. The importance of the *use* phase becomes even more evident when considering the problems of *rebound effects* (Herring & Roy 2007), i.e. the effect that despite increased product efficiency the overall consumption increases. For instance, fuel-efficient cars often entail a higher usage of such cars (i.e. road kilometres). This behaviour results in higher resource consumption, although the resource-efficiency is increased. Hence, user behaviour and customer needs play a major role for SOI and need to be integrated into the development process.

- Fifth, the *end-of-life* phase ultimately impacts the sustainability of products. The potentially most renowned example of an end-of-life problem is nuclear power technology. Though carbon free energy production is possible (neglecting here the efforts for extracting and sourcing of uranium), there has been no ultimate solution yet for how to effectively deal with radiated waste from power plants. Other important guidelines to consider are recycling options (e.g. cradle-to-cradle principles), materials with health or safety risks (e.g. quicksilver in energy saving lamps), corporate take-back programs, among others.

Though reference is made here to the entire life-cycle, it is clear that not all phases can always be considered with the same level of detail in innovation efforts. Often, hotspot analyses lead to a focus on the most important phases (e.g. the use phase for white goods; supply chain for textiles). Moreover, some of the life-cycle phases are non-existent for some types of goods. For instance, consumable goods (e.g. electricity) usually lack the end-of-life phase and digital goods may or may not have a packaging (depending on the distribution channel). Even pure services (e.g. catering) can be analysed along the life-cycle though, by definition of services, production and use phases merge into one (it should be mentioned that very labour-intensive services such as elderly care may be radically focused on the use phase and thus need other ways of analysis).

<table>
<thead>
<tr>
<th>Target dimension</th>
<th>Life-cycle phases</th>
<th>Supply chain</th>
<th>Production</th>
<th>Packaging/distribution</th>
<th>Use (maintenance)</th>
<th>End of life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>Competitive</td>
<td>Production efficiency</td>
<td>Efficient packaging; efficient logistics</td>
<td>(Technical/functional) quality; customer satisfaction</td>
<td>Costs of take-back/disposal/landfill</td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>Use of eco-friendly (e.g. organic) materials; energy-efficient production, use of renewable energies, and environmental protection at supplier’s site</td>
<td>Eco-efficient resource and energy use; use of environmental friendly materials and processes; renewable energy; closed-loop production; industrial symbiosis</td>
<td>Reduced packaging resources; use of ecological or recycled materials; minimised transports; eco-efficient fleet</td>
<td>Durability; energy-efficiency; emission reduction; offering of maintenance/repair services</td>
<td>Re-use, re-make, or recycle (upcycle); in the case of disposal: biodegradability; treatment of dangerous materials</td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>Safe and fair labour conditions (e.g. no child labour); smallholder integration; socio-economic development of regions</td>
<td>Occupational health &amp; safety; labour conditions; wages; employee benefits</td>
<td>Truthful product description and labelling (packaging); working conditions (e.g. outsourced personnel)</td>
<td>Customer health &amp; safety; complaint handling; increase access to product (e.g. inclusive business)</td>
<td>Health threats of landfills and recycling plants</td>
<td></td>
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</tbody>
</table>

Table 1 Sustainability challenges and solutions along the physical life-cycle of a product (based on Hansen et al. 2009)
Which types of innovation relate to SOI?

Outcomes of innovation are often classified using different innovation types. Whilst SOI roots in new product development, and thus in a product innovation perspective, the concept of SOI is indeed much broader and relates to or covers various other types of innovation. In the present chapter, links to these innovation types are explained. Considering that the recognition of the life-cycle dimension is central to SOI, it is also clear that SOI covers not only product innovations but also process and organizational innovations (Rennings 2000). For instance, the introduction of sustainability criteria in procurement policies, more efficient production processes and the implementation of processes for product take-back are all examples of process innovations. Often these process innovations, particularly in the phase of production, are supported by new environmental or integrated management systems, which in turn are an example of organizational innovations.

The traditional focus of innovation often lies on the development of technically improved or entirely new products and processes, thus on technological innovation. Whilst these efforts are very important, they alone cannot solve some of the overarching sustainability challenges, particularly increased absolute resource consumption and waste. On the one hand, efficiency gains in the product's use phase (e.g. fuel efficient cars) - due to rebound effects (Herring & Roy 2007) - are mostly over-compensated through more intense use. Also, many of the life-cycle improvements (e.g. recycling) depend on increased interaction between the producer and consumer (product take back system) and thus require innovative solutions beyond the technological level.

Against this background, product-service systems (PSS) [cf. Product-Service Systems] can be considered an additional type of innovation for leveraging SOI. Product-service systems are generally referred to an increasing service content of products (Mont 2001). By increasing the service portion of innovations, the consumption of resources can actually be decoupled from its value proposition and therefore poses great advantages for SOI. Indeed, at least three different product service combinations qualify for this (Baines et al. 2007; Mont 2001; Tukker 2004):

- **Product-oriented PSS** add a service to the initial product. For example, the product take-back service (end-of-life phase) allows the producer to recycle or remake the product and thus contributes to environmental (but also to economic) value.
- **Use-oriented PSS** are product-based services that are based on product rental and leasing rather than selling. A good example is the case of Interface Inc. which originally focused on selling carpets, but later became renowned for its flooring services based on leased carpets. Instead of replacing entire carpets, the company only replaces worn tiles (Stubbs & Cocklin 2008). Use-oriented PSS can also be based on shared use, i.e. consumers (or users) use the same product either subsequently (e.g. public washing machines; car sharing) or simultaneously (e.g. ride sharing services; Hansen et al., 2010).
- **Result-oriented PSS** are also offerings where the producer remains in the ownership of the product but, in contrast to use-oriented PSS, the producer only sells a result (e.g. laundered clothes instead of washing machines).

The latter two variants of (product-based services; result-oriented PSS) are function innovations because instead of concentrating on how to improve the product, such innovations focus rather on how the product’s function is best (and most sustainably) fulfilled (Brezet, 1997). As demonstrated in the various mentioned examples, PSS are based on the prior product (e.g. car) but solve some of the sustainability-related problems on the level of the PSS (e.g. carsharing). Function innovations can actually supersede the original product: for
instance, bike sharing systems represent more sustainable (and ever more popular) alternatives to car-based mobility in cities (e.g., call-a-bike system in Germany).

Whilst function innovation try to satisfy given needs (e.g., need for private mobility) with alternative solutions, innovation efforts can also address (and question) customers’ “needs” on a higher level (Belz et al. 1998; Paech 2004). With regards to SOI, this notion is extremely important, as need structures and lifestyles are deemed one of the major causes for sustainability issues. This relates to the question whether or not corporations should modify or “design” the needs of customers/consumers. For example, a travel company could make efforts to redirect the customers’ need for holidays in the Caribbean towards more local travel destinations (Paech 2004). In the extreme, a company could question the customer’s need entirely, such as in the “Don’t buy this jacket” advertisement of Patagonia, the environmental pioneer in the outdoor apparel industry. The development of alternative solutions and sufficient lifestyles (cf. Lifestyle of Health and Sustainability [LOHAS]) can be considered as source of innovation with positive sustainability potentials (Hockerts & Morsing 2000; Mont & Tukker 2006). Notably, those issues go far beyond traditional tasks of innovation management and entails questions also related to sustainability marketing (Belz 2012; Louche et al. 2010).

The presented function innovations (and thereby also most of the PSS innovations) all require adaptations to a varying degree of a company’s business model, and thus it is often spoken of business model innovations (Chesbrough 2007; Hansen et al. 2009; Schaltegger et al. 2012; see also [Business Model Innovation]). For example, a car manufacturer engaging in car sharing services follows an entirely new value proposition linked to new pricing and revenue models, completely changed sales organization, and (probably) new partners in the value chain. Business model innovations are thus a very important tool for SOI, particularly regarding the most radical (or even disruptive) innovations.

How to design innovation processes for SOI?

The framework and dimensions involved with SOI made clear that SOI, particularly due to the directional risk, are more complex than conventional innovation projects (Paech 2007). It is thus even more important to highlight the role of innovation management to initiate and support such projects. Therefore it is crucial to embed the holistic concept of SOI (i.e., target dimension covering social, environmental and economic capitals; life-cycle dimension covering phases from resource extraction to end-of-life; and innovation types beyond product and processes) as a fundamental element into innovation processes (Fichter & Paech 2004; Hansen et al. 2009; Lang-Koetz et al. 2009). Only the systematic integration into the (semi-)formal innovation processes as well as the innovation culture can guarantee the recognition and incorporation of such complex issues.

Though in reality innovations occurs usually in an unsystematic, iterative process, with the aim of analytical clarity, the innovation process is often presented as a linear process. It spans across several stages, such as problem definition, idea generation, idea evaluation, concept development, prototype, and market launch, each separated by a gate in which the innovation projects are evaluated before proceeding further (Cooper 1990; Fichter & Paech 2004; Lang-Koetz et al. 2009; Tidd et al. 2009). One, often neglected but with regards to SOI quite remarkable phase, is the one of problem definition. Narrowing down the innovation focus too early on products and technologies or never even questioning such focus can hinder the development of product-service systems, which in turn have a much larger sustainability potential. Another way of integrating SOI into the innovation process are sustainability checkpoints as part of the screening stages after each phase of the idealized stage gate process (Blomquist & Sandström 2004). These checkpoints can cover different assessment levels and mechanisms. For instance, technology assessment and related social and environmental risk analysis are methods important at the beginning of the innovation process, particularly in the case of risk technologies (Fichter & Paech, 2004; Paech 2004, 162). It should be noted that eighty percent of sustainability
effects can already be addressed in the conception stage (Maxwell & Van der Vorst 2003). Also, (streamlined) LCA methods could be used in the (early phases of the) innovation process in order to evaluate potential environmental impacts along the entire product's life-cycle (Lang-Koetz et al. 2009).

Whilst the approach of checkpoints and screening tools are a rather mechanistic approach, a complementary approach focuses on the individuals involved in the process. As the dimensions of SOI aforementioned indicate, extensive knowledge on environmental and social structures and relationships is crucial, yet traditionally not sufficiently located in corporations. Traditionally, knowledge creation is the responsibility of the corporate research and development (R&D) function (i.e. closed innovation). However, “open innovation” (Chesbrough 2003) is also an important mechanism to address SOI, as internal company members are often not fully aware of potential social and environmental impacts. The involvement of actors outside of the organization is particularly important to increase the reflexivity of the innovation process and thus lower the directional risk involved in SOI (Fichter & Paech 2004; Paech 2007). The interaction with a wider range of stakeholder groups (e.g. non-governmental organizations, community members, local authorities) through mechanisms such as stakeholder dialogue fora, stakeholder advisory boards, joint management stakeholder boards, and partnerships can address these shortcomings by facilitating dialogue [see Stakeholder Engagement]. Furthermore, a more direct involvement of outside actors into the innovation process may pose high potentials for the development of SOI. For example, in the ideation phase “idea contests” help to open the innovation process and involve more stakeholders which may contribute to the development of sustainability-oriented products (Hansen et al. 2011). In addition, broader crowd-sourcing approaches applied in later phases of the innovation process can contribute to this endeavor (Hansen et al. 2010). Lead user workshops, also covering environmental experts, help to successfully design sustainability-oriented products and services (Arnold et al. 2007; Hoffmann, 2007).

Another issue of innovation management, which heavily impacts the development of SOI, is the creation of an innovative organization or an innovation culture (Tidd et al. 2009, p. 465ff). What are the values a company and the R&D function is based on? How are managers, especially R&D managers, trained and developed, incentivized, measured, and rewarded? If innovation success is only interpreted in mere economic terms (e.g. sales figures, cost structure, etc.) it is hard to imagine that the company would spend time, money and thoughts on how to address social and environmental aspects in the process.

Hence, SOI pose a variety of challenges for innovation management and the related innovation processes, i.e. the adaptation of innovation processes to include better evaluation and screening methods - already in early phases of the process, the integration of external knowledge and stakeholders and the development of a sustainability-oriented innovation culture.

**Future Directions**

In order to further develop the concept of SOI, various challenges need to be addressed in the future:

- **Radical innovations.** Several studies show that the efficiency of current use of resources must increase by a factor of about ten to fifty in order to achieve sustainability (Tukker & Tischner 2006). Such efficiency leaps demand more than just incremental improvements. They also need radical innovations. This covers developing and diffusing radically more sustainable technologies and products (e.g. renewable energy; decentralised heat combustion production; electric cars), product-services systems and entirely new business models (e.g. carsharing). But, in recognition of the life-cycle perspective, it is also about radical process innovations. Examples can be taken from agricultural-based industries where more and more companies switch to organic agriculture (e.g. organic cotton; organic food) and integrate smallholders into their supply chains (Bright & Seville 2010). Another radical process innovation can be seen in the textile industry where some companies have established vertically integrated production in their home markets (e.g. American Apparel in the US, or Manomama in Germany) instead of low-cost sourcing models from Asian countries –
this allows for dramatically reduced carbon emissions and better control over labour conditions (Plieth et al. 2012; Porter & Kramer 2011).

- **Open innovation.** Particularly in large-scale corporations, innovation is traditionally the responsibility of the corporate research and development (R&D) function, often referred to as closed innovation. However, as it has been stressed in this article, organizations should also think more strongly in terms of open innovation as an important mechanism to address SOI; internal company members are often not fully aware of the full range of potential social and environmental impacts. The interaction with a wider range of stakeholder groups (e.g. non-governmental organizations, community members, local authorities) and their systematic integration in the innovation process, for instance, through collaborative innovation workshops, is key to advance towards SOI.

- **Capacity building for SOI.** As described above, SOI poses new challenges for innovation management. Often companies both large scale corporations as well as small and medium-sized companies (SMEs) cannot deal with the SOI-related challenges in isolated ways and thus require some form of capacity building for SOI. Company networks and clubs, university-industry linkages and public-private partnerships are all possible means to advance the SOI agenda collaboratively. Successful public-private partnerships such as Ecoprofit in Europe demonstrate that collaborative approaches can be effective (e.g. Klewitz et al., 2012).

- **Sustainable entrepreneurship.** Radical innovations also lie at the heart of the related concept of **sustainable entrepreneurship** (Hall et al. 2010; Hockerts & Wüstenhagen 2010; Schaltegger 2002; Schaltegger & Wagner 2011). This concept can be understood as “an innovative, market-oriented and personality driven form of creating economic and societal value by means of break-through environmentally or socially beneficial market […] innovations” (Schaltegger & Wagner 2011). Both entrepreneurial firms (through entrepreneurs) and incumbents (through intrapreneurs) can engage in sustainable entrepreneurship, however, they play different roles in the transformation of industries (Hockerts & Wüstenhagen 2010). Sustainable entrepreneurs introduce radically more sustainable offerings in niche markets and put their larger counterparts under pressure, either by growing into the mass market or by simply demonstrating alternative (technological) solutions. More efforts should be undertaken to understand the transformation of industries from this entrepreneurial perspective.

- **No innovation?** Whilst the potentials of innovation for sustainable development have been discussed at length in this article, the almost ideological innovation orientation of today’s company’s is also considered to be a challenge to sustainable development (Paech, 2004). Innovation is still too often linked to further resource consumption and economic growth at the cost of environmental sustainability. Sometimes it may also be beneficial to stick to existing (best) practices instead of reinventing the wheel. The recent trend of organic agriculture is an interesting example for the revisit of ancient forms of agricultural production which deliberately ignores some of the modern day’s technological achievements (e.g. chemical fertilizer; pesticides). A critical reflection of the concept of innovation itself is thus an important topic for research and practice.

**Cross-References**

- CSR innovation
- Eco innovation
- Ecopreneurship
- Life-cycle analysis
- Product-service systems
- Stewardship theory
References


