innovating for sustainability

A Systematic Review of the Body of Knowledge

Network for Business Sustainability

Business. Thinking. Ahead.

nbs.net

Prepared by
Richard Adams
Sally Jeanrenaud
John Bessant
Patrick Overy
David Denyer

"... [S]mart companies now treat sustainability as innovation's new frontier."

Ram Nidumolu, C.K. Prahalad and M.R. Rangaswami in Harvard Business Review

Through innovation, companies can build more sustainable products, processes and practices that benefit the firm and society.

Innovating for Sustainability

A Systematic Review of the Body of Knowledge

Prepared by Dr. Richard Adams, University of Exeter; Dr. Sally Jeanrenaud, University of Exeter; Dr. John Bessant, University of Exeter; Patrick Overy, University of Exeter; Dr. David Denyer, Cranfield University School of Management; with research assistance from Hannah Metcalfe, University of Exeter.

Additional resources are available at:
nbs.net/knowledge

Dear Reader,

I'm pleased to share with you this report on innovation for sustainability. Innovation is fast becoming one of the most exciting topics in business. Innovation focuses on the opportunities, instead of risks. It mobilizes positive action, rather than paralyzing business in inaction. It allows us to imagine new futures — ones in which business works hand-in-hand with society.

This report outlines specific practices that have been shown to help firms innovate for sustainability. It also identifies the conditions and contexts in which innovation is more likely to work. I especially encourage you to examine the innovation model on page 17, and the associated practices on page 20 to 21. Together, these show the steps of the sustainability journey. Managers can use these to benchmark firm activities and highlight new ways of thinking about sustainability-oriented innovation.

This research was authored by a team that included Dr. Richard Adams, Dr. Sally Jeanrenaud, Dr. John Bessant, Patrick Overy, Dr. David Denyer and Hannah Metcalfe. Dr. Denyer is from Cranfield University School of Management; his colleagues on the team are from University of Exeter. This research also benefited from valuable insights from the team's academic advisor, Dr. Stuart Hart (Cornell University), and its guidance committee: Dan Burt (Suncor), Scott MacDougall (Suncor), Wendy Perkins (RIM), Matt McCulloch (Pembina Institute), Luc Robitaille (Holcim) and Georgina Wainwright-Kemdirim (Industry Canada).

This systematic review is one of many that form the backbone of NBS. The topics are chosen by our Leadership Council, a group of multi-sector organizations leading in sustainability whose names you will find at the end of this report. This group meets annually to identify the sustainability topics most salient to business. Identifying what innovation activities firms engage in to become more sustainable was near the top of their list for 2012. The reports from all their past priorities are available freely on our website at nbs.net.

We are proud of our systematic reviews. Popularized in the field of medicine, they systematically and rigorously review the body of evidence from both academia and practice on a topic. The result is an authoritative account of the strategies and tactics of managing sustainably, as well as the gaps for further research. I hope this report will help you understand how you and your organizations can enhance your innovation to reach more sustainable outcomes.

Sincerely,

Tima Bansal, PhD
Executive Director, Network for Business Sustainability
Professor, Richard Ivey School of Business

table of contents

introduction

This systematic review identifies activities that firms should be doing to adapt their innovation systems to drive sustainable outcomes.

Firms can innovate toward sustainability through a series of small incremental steps or through more radical, disruptive transformations. We call these different contexts “Operational Optimization” and “Systems Building.” A third context, “Organizational Transformation,” is transitional.

Businesses face increasing pressure to change. This pressure is both internal and external. Businesses have historically seen themselves as separate from the rest of society. As a result, they have been singled out as being particularly responsible for environmental and social harms. Now, many businesses are recognizing the opportunities of greater integration with the world outside their boundaries. Firms are also being asked, and sometimes are obliged, to attend to the environmental, social and economic implications of their activities. Together, these factors (people, planet and profit) constitute the Triple Bottom Line[1] (TBL) of business sustainability (Elkington, 1997).

In the future, firms will need to adopt more sustainable practices and outputs if they are to retain their legitimacy — their social licence to operate — and thrive. Thus, the ability to innovate in the domain of sustainability is a capability that firms need. But is Sustainability-Oriented Innovation (SOI) any different from more traditional forms of innovation; and, if so, what defines it?

Some firms are keen to respond to these challenges, but are unsure of the actions they need to take. They need guidance to identify and adopt SOI practices. Other firms have already responded to the sustainability challenge and may see themselves as part of the solution rather than part of the problem. These firms need direction on how to progress.

To help firms move toward sustainability, Network for Business Sustainability commissioned this systematic review of the literature relating to the practice and management of SOI. This systematic review provides guidance by identifying activities that firms could and should be doing to adapt their innovation systems and thereby drive sustainable outcomes. Consequently, in this review, we address the question:

What innovation activities do firms engage in to become sustainable?

It became apparent early in our review that two schools of thought have emerged: one sees SOI as a series of small incremental steps in the right direction, and the other sees the need for more radical, disruptive transformations. Based on these insights, we developed a model (Figure 1) that distinguishes between these different contexts of SOI, which we term “Operational Optimization” (small, incremental changes) and “Systems Building” (radical, disruptive changes). The relative size of each context in Figure 1 suggests the distribution of the literature. Further, we argue that the move from Operational Optimization to Systems Building requires an abrupt step-change, both in mindset and behaviour, and that numerous firms have entered a period of Organizational Transformation as they experiment with moving toward Systems Building.

[1] Also referred to as the integration of social, environmental and economic considerations (Elkington, 1997).

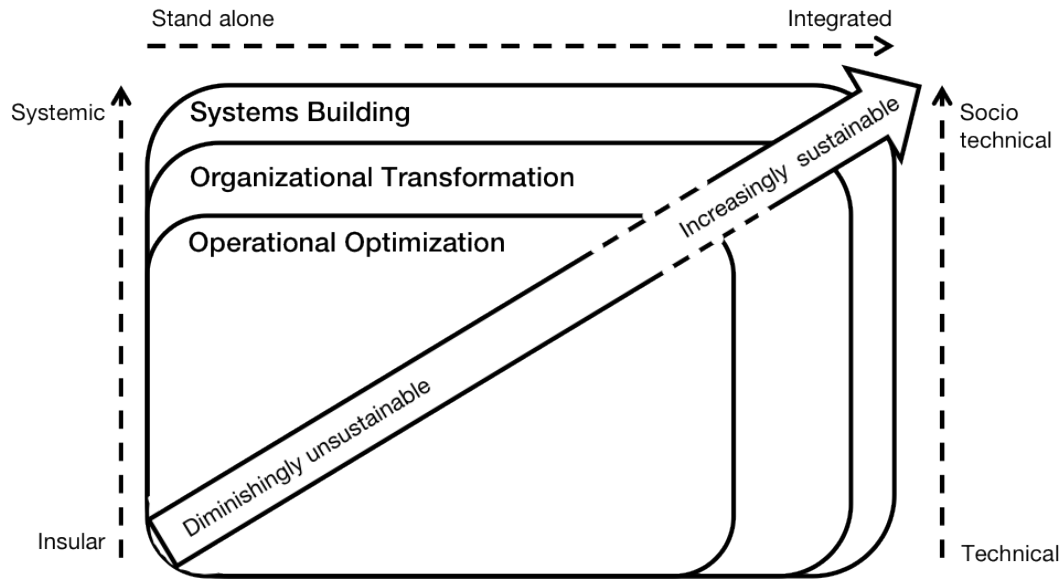
To address the needs of all firms, it is valuable to map, learn from and share the experiences of both Operational Optimizers and the rare, pioneering Organizational Transformational firms. Many firms still need support to learn how to embark on becoming sustainable. Consequently, in this review we address the questions of how firms can become more "green" and how they can progress "beyond green."[2] In fact, we found no empirical evidence of firms in the final context of Systems Building. Rather, it represents an ideal or aspirational state, a logical extension of the ambition, experimentation and exploration evident among Operational Transformers.

This model, which is fully explained on page 17, has helped guide us in the analysis of the primary studies. Our findings are based on a review of 100 peer-reviewed academic journal articles and 27 non-academic sources (see Appendix 1 and Appendix 2 for methodology and descriptive analysis). In our exploration of SOI, we move from a general discussion of the phenomenon to a more specific consideration of SOI activities. The remainder of the report is organized as follows.

First, we provide a short history of SOI and highlight the characteristics that distinguish it from more traditional innovation. Next, we describe the development of

Figure 1

THREE CONTEXTS OF SUSTAINABILITY-ORIENTED INNOVATION



[2] The use of the word green is something of a double-edged sword. It is a powerful symbolic articulation of one aspect of sustainability thinking, a rallying post around which debate and action can muster. On the other hand, it obscures the wider meaning of sustainability, and the social dimension is often lost.

our model, grounded in the academic literature, and elaborate on its significant dimensions. We then describe specific SOI activities in the contexts of Operational Optimization, Organizational Transformation and Systems Building. This section is followed by a brief discussion, and we conclude the review by contextualizing our findings with previous systematic reviews on related subjects.

We hope that the findings of this review stimulate discussions both among managers and senior executives regarding how their firms might move toward sustainability and among policy makers looking to support businesses in their transitions toward sustainability. Managers can use the proposed model to reflect on the extent to which their existing and planned activities move their firms both upward and rightward in the model — toward sustainability. More specifically, the list of activities can be used to benchmark firm activities and highlight new ways of thinking about SOI. When applying our findings to their own firms, managers must also consider their own firms' particular conditions. We believe this framework provides a helpful tool to guide managers' thinking and decision-making in relation to SOI. Our purpose is to help managers to understand what they can do to build and nurture a sustainable organization.

origins of SOI and its relation to traditional innovation

Over the past 20 years, Sustainability-Oriented Innovation (SOI) has evolved to be seen as a competitive advantage.

SOI and conventional innovation have much in common. Both address technological change and involve evolutions in processes, practices and business models. As a result, firms with established innovation capabilities are well positioned to become sustainability-oriented innovators. But, because the sustainability orientation incorporates social and environmental dimensions alongside economic ones, it introduces new challenges. Especially as it progresses, SOI requires more integrated thinking. Firms must reconsider their capabilities, stakeholder relationships, knowledge management, leadership and culture.

We began our review with articles from the early 1990s,[3] when Sustainability-Oriented Innovation (SOI) was thought of principally in terms of firms' environmental impacts and their technological solutions. Solutions were then regarded by many managers as an additional cost to the firm. The dominant strategic orientation was reactive; implementing environmentally related innovations was seen as a necessary response to regulatory obligations.

The traditional argument that polluting firms are competitively disadvantaged by the obligation to reduce their emissions has been countered by Porter and Van Der Linde (1995) among others. They argued that firms can benefit from first-mover advantages, economic efficiencies and reputational enhancement. That is, adoption of an environmental orientation can contribute to, not detract from, a firm's competitive advantage.

Twenty years later, the tenor of the literature reflects an evolved perspective: many firms are increasingly proactive, innovating in the domain of sustainability for reasons of both compliance and competitiveness. They are also motivated by a wider systems/common futures perspective that adopts more responsible positions in terms of the social and environmental impacts of their business activity.

Contemporary firms are experimenting with novel practices that extend the idea of sustainable business beyond eco-efficiency to fully integrate sustainability thinking as a core business driver and into all aspects of their operations and relationships. Firms are forming new collaborations, embedding themselves in local and global communities and experimenting with new business models and with new models of innovation, such as *frugal innovation, resource-constrained innovation, reverse innovation* and *jugaad innovation*.

SOI AND TRADITIONAL INNOVATION

Our findings suggest that SOI and traditional innovation have much in common. Both address technological change and innovations in processes, in operating procedures and practices, in business models and in systems thinking. Because of these commonalities, firms with existing innovation capability are well positioned to become sustainably-oriented innovators. Their already-developed innovation capability is an important antecedent of their capability for SOI. Similarly, firms should be able to easily integrate sustainability dimensions into any already adopted quality systems such as Six Sigma or ISO 9000.

In the context of Operational Optimization, the first and typically incremental SOI stage, innovation for SOI may not be a radically different phenomenon from a firm's previous innovation activities. Many sustainable innovations, particularly those related to the environment, are not radical — they reinvent the wheel. They do what existing technologies already do, but in a more ecologically efficient manner. Further, the values that underpin conventional innovation also underpin SOI in this context: added value or cost reduction and, ultimately, either increased revenues from existing

[3] Our review focuses on the period from from 1992 (marked by the Rio Summit) to 2012.

customers or the acquisition of new customers (Carrillo-Hermosilla, Del Rio & Könnölä, 2010).

However, by adding environmental and social considerations, SOI is differentiated from conventional innovation in its purpose and direction (Bos-Brouwers, 2010b). As SOI progresses, it increasingly requires more integrated thinking, connecting a wider range of considerations than those that characterize traditional innovation. More progressive firms are looking to ensure that sustainability practices are embedded in all decisions and processes throughout the business.

Many companies have embraced the practice of environmental management, but few have seriously engaged the idea of sustainability (Shrivastava & Hart, 1995), and moving beyond Operational Optimization requires a radical approach. A sustainability orientation then renders innovation more complex and ambiguous. Once firms are in the Organizational Transformation context, its complexities include the following:

- Balancing the three dimensions of the TBL and, in particular, paying greater attention to the social and environmental dimensions
- Embedding appropriate tools and processes to enable implementation of SOI across the firm
- Involving and engaging with a wider range of external stakeholders with potentially competing interests to work toward systemic change, such as extending sustainability thinking to suppliers and customers who may lack experience, knowledge and confidence in SOI
- Developing new mechanisms to access specialist knowledge and expertise
- Acquiring appropriate search skills to respond to new knowledge requirements
- Redefining who key stakeholders are and ensuring that their interests are understood and incorporated into decision-making
- Investigating life cycles of products, the origins and sustainability of raw materials, the physical and social consequences of production and consumption, and the fate of products at the end of their useful life
- Integrating sustainability thinking more deeply into organizational behaviours and processes through leadership and a culture conducive to changing and reframing the purpose of the firm (i.e. embedding economic activity in society)
- Unlearning existing competences as the current models of innovation, and research and development (R&D) may not be sufficient to deliver a sustainable business

In summary, the integration of economic, social and environmental considerations distinguishes SOI from conventional innovation, rendering the SOI process more complex and challenging, especially as it progresses. Thus, SOI has significant implications for a firm's capabilities; its networks of stakeholder relationships; its knowledge management (particularly its ability to acquire, assimilate and exploit new knowledge); the firm's wider systemic relations; its visionary leadership and culture for SOI; and the integration of sustainability into products, services, practices and strategy.

The next chapter describes the framework and its developments in more detail and begins to outline associated innovation activities. Pages 22 to 56 illustrate the practical use of innovation activities in detail and the changes in thinking and practice required to move from Operational Optimization to Organizational Transformation.

constructing a model of SOI

Past research on SOI helped shape our model of the three contexts: Operational Optimization, Organizational Transformation and Systems Building.

As firms move from Operational Optimization to Organizational Transformation, they change across several dimensions:

- Firms become systemic – interested in connections with society – rather than insular (inwardly focused)
- Innovation becomes integrated throughout the firm rather than a stand-alone, “add-on” activity
- Innovation incorporates social as well as technical considerations
- Firms move from reducing harm to delivering benefits to society

Specific practices are associated with each context.

We developed our model of contexts of SOI by drawing on previous definitions and academic models of SOI (see Appendix 3 and Appendix 4 for a full description of these definitions and models). Many competing conceptualizations exist, and there is little consensus. In this chapter, we identify the elements of past models that we incorporated into our model. We then present our model: specific dimensions and contexts of SOI.

DRAWING FROM PAST MODELS

In defining SOI, some studies draw inspiration from Our Common Future, the report by the World Commission on Environment and Development (WCED, 1987), commonly referred to as the Brundtland Report (see Appendix 3). This report emphasizes the environmental, social and economic aspects of sustainable development, such as resource limits (energy, materials, waste and land), equitable access to constrained resources, inter-generational and intra-generational equity, and a progressive transformation of economy and society (Stubbs & Cocklin, 2008).

However, although drawing on the Brundtland Report, most studies define SOI much more narrowly, adopting an eco-innovation perspective internal to the firm (e.g. Fussler & James, 1996). Only at the turn of the century does the perspective broaden to include the social dimension and integrate the world outside the firm. For example, George et al.'s (2012) conceptualization of inclusive innovation explicitly meshes the economic objectives of firms with opportunities to enhance the social and economic wellbeing of disadvantaged members of society. Another conceptualization includes "products, processes, marketing methods and organizational methods, but also … innovation in social and institutional structures" (Machiba, 2010, 360).

Some researchers' definitions view SOI as reducing the harmful impact of operations; other definitions see it as oriented toward making a positive net contribution. Later definitions and those that more holistically conceptualize sustainability incorporate the idea of a positive contribution (e.g. Bos-Brouwers, 2010a; Klewitz & Hansen, 2011; George, McGahan & Prabhu, 2012).

Clearly, SOI has many aspects. SOI incorporates multiple considerations (environmental, social and economic), has wide influences (on products, processes, value chains, business models, institutions and the wider community) and introduces new relationships and bodies of knowledge. This review defines SOI broadly. For a sustainability-motivated firm, one that either wants to begin to adopt sustainability practices or is already on that path and seeking to improve, any review of SOI must embrace this range of aspects.

STAGES OF SOI

Many earlier models of SOI (Appendix 4) adopt the metaphor of "sustainability journey" and suggest that firms pass through a set of stages as sustainability considerations become more integrated into their core thinking and processes. The models are inconsistent, however, with respect to the point of departure, the number of stages, stage duration, how to move from

one stage to the next and the end point. However, the models do offer a general indication of direction of travel for SOI.

Together, earlier models portray a dynamic but challenging process. In the early 1990s, a principal concern of research was the legitimacy of sustainability thinking within business decision-making. Because the case for the sustainability approach has largely now been made, models increasingly view the initial stages of SOI as a series of gradual changes, with incremental innovations addressing specific issues. Such innovations focus on technological change around products and processes, reflecting a compliance-based or risk-reduction orientation. Initially, firm behaviour may be unsystematic and reactive — even reluctant — but can become more deliberate as sustainability thinking becomes more widely embraced within the firm and integrated into day-to-day activities (e.g. the management of inputs, processes, suppliers and products). The innovation focus moves to clean up polluting processes and subsequently to efficiency-driven environmental or social management: innovation to optimize efficiencies. Internal systems are redesigned to become less environmentally burdensome. Modified and new products, processes and services emerge, but within the prevailing context and market framework.

Models exploring the innovation territory beyond compliance and optimization suggest the need for a fundamental shift in innovation thinking and practice. This shift moves the firm from a passive or reactive relationship with environmental and social considerations through the development or redesign of sustainable offerings to find novel ways of delivering and capturing value, which will change the basis of competition (Nidumolu, Prahalad & Rangaswami, 2009: 60).

This approach can be conceptualized as a shift from "business-as-usual" thinking characterized by established routines for searching, selecting and implementing, to "doing things differently" through significant modification — or even abandonment — of existing routines and the development of new ones. Such innovation goes beyond reviewing the relationship between a product and the environment, to rethinking production, consumption and delivery; imagining new outcomes and understanding; and leveraging the interdependencies of system components (Seebode, Jeanrenaud & Bessant, 2012). Such learning and "unlearning" may be a particular challenge for incumbent firms, but may be less so for new entrants who are unconstrained by legacies.

Some models show a distinct shift toward greater proactivity and more strategic sustainability management. Technological solutions give way to innovation extending beyond the boundaries of the firm. The motivation changes from reducing harm to making a net positive impact. The firm transforms by revisiting values, culture, purpose, relationships and practice (McDonough & Braungart, 2002).

The most contemporary model we reviewed is Elkington's (2012) Pathways to Zero. It is a vision of new business models and new forms of value; of new and extensive partnerships reaching deep and wide across social, institutional, regulatory and stakeholder strata; and of wider cultural change beyond the capacity of enterprises to control but the development of which they can motivate and inspire.

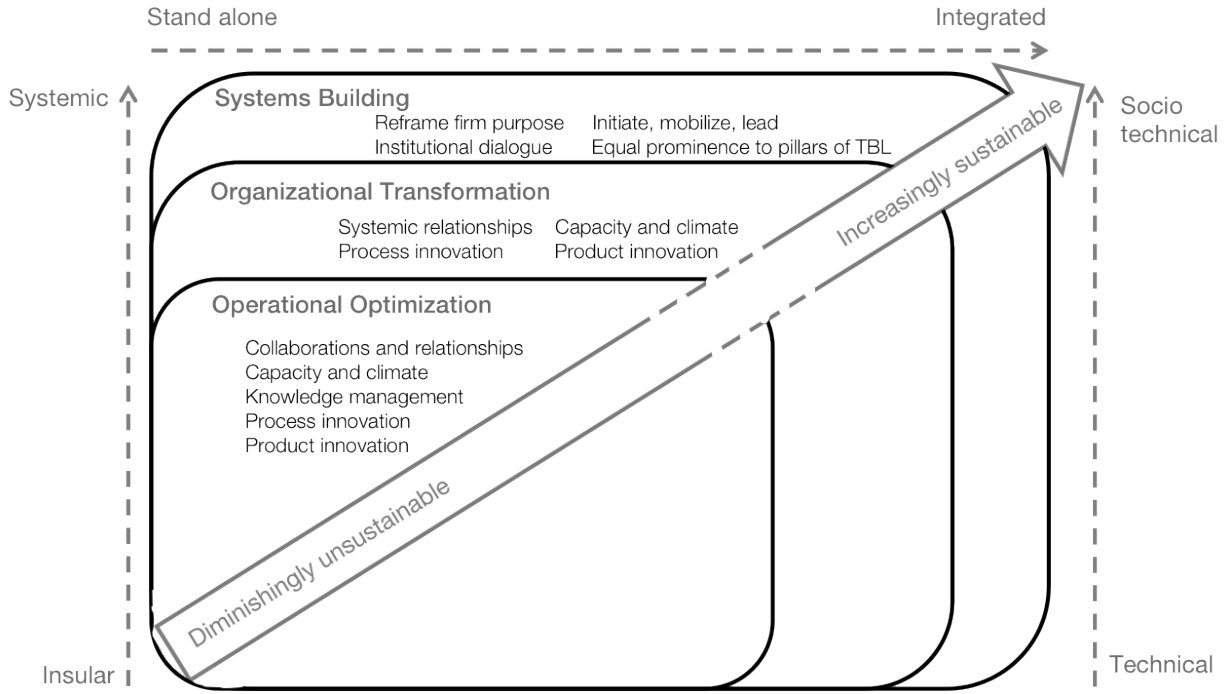
From the models reviewed, we envision a speculative frontier of SOI practice. This frontier is characterized by sustainability that is not only embedded in the firm but is the firm's purpose, where attempts are made to give the three elements of the Triple Bottom Line equal prominence in organizational decision-making and action. No clear empirical instances of such firms exist; some firms aspire to this position but it is difficult to reach.

the model

We draw on the preceding review to develop a model of three contexts of SOI. We label these contexts Operational Optimization, Organizational Transformation and Systems Building. In Figure 2, categories of SOI activity are mapped into each of these contexts.

Figure 2

CATEGORIES OF INNOVATION ACTIVITY IN THE THREE CONTEXTS OF SUSTAINABILITY-ORIENTED INNOVATION



The literature has traditionally distinguished between eco-efficiency and eco-effectiveness, and these concepts map well onto the first two categories we propose. However, we prefer the labels Operational Optimization and Organizational Transformation, which acknowledge both the social and environmental dimensions of sustainability.

In Operational Optimization, firms seek to diminish the harmful consequences of their business activities. For example, the focus on technological innovations may reduce emissions generated during processing or manufacturing, minimize the use of non-renewable materials or replace toxic components with either renewable or more benign alternatives.

At the other end of the SOI scale, Systems Building recognizes that simply reducing elements of unsustainability will continue to deplete resources, degrade the environment and emit pollutants — only less rapidly. For example, the global economy is arguably locked into a "carbon model" that constrains innovation into fossil fuel-dependency: incremental changes in engine efficiency or manufacturing processes, while laudable, will not lead to sustainability. Systems Building describes, instead, a strategy of seeking to become increasingly sustainable rather than less unsustainable, in line with the ambition in the Brundtland Report (WCED, 1987, paragraph 49), to conduct business operations in ways that "meet the needs and aspirations of the present without compromising the ability to meet those of the future."

Both types of innovation orientation are arguably important. Still, reducing unsustainability, despite delivering substantial improvements, is insufficient: its gains are often offset by increased consumption or production (Machiba, 2010). This mode of innovation may be a stepping stone toward greater sustainability. The leading edge of SOI, however, is characterized by Systems Builders, firms experimenting with changes to their business models, wider institutional change and alternative delivery of products and services.

The shift between Operational Optimization and Systems Building is complex, marked by a phase of Organizational Transformation. During this phase, firms shift from a focus on reducing harmful impacts toward delivering social, environmental and economic benefits both for themselves and the wider society. During Organizational Transformation, firms' innovation activities become increasingly systemic, integrated and socio-technical. On the basis of this analysis, it is possible to further map the SOI landscape.

Dimension 1: Insular/Systemic: This dimension reflects how the firm sees itself within a wider system. Does the firm see itself as part of society or as standing apart from society?

More progressive SOI firms look beyond their boundaries to address the SOI challenge, paying attention to wider systemic considerations. Their innovation initiatives engage with and facilitate change in wider systems. These efforts may include influencing value chains or engaging with wider communities and forming coalitions with stakeholders such as NGOs, lobby groups and governments.

Dimension 2: Stand-alone/integrated: This dimension is internal to the firm and describes whether innovations are stand-alone or integrated into the firm through departments, functions, vision and strategy. SOI moves from being an "add-on" activity to a philosophy suffused throughout the organization.

Firms often innovate initially to comply with regulations and then to optimize efficiencies derived from SOI — in other words, moving from stand-alone innovation to an approach that is integrated into the processes, practices and culture of the firm. Stand-alone innovation addresses sustainability piecemeal, tackling single issues such as pollution control through end-of-pipe technologies. In contrast, integrated innovation might use information systems to connect disparate functions around a set of sustainability goals. Firms that progress with the sustainability journey adopt such an approach, embedding their sustainability into core processes and strategic thinking. SOI will have limited reach unless sustainability is fully embedded in all decisions and processes of the firm.

Dimension 3: Technological/Socio-technical: Innovation changes as firms exhibit a stronger orientation toward this dimension: technological innovation gives way to greater socio-technical innovation. Innovations are said to be socio-technical when they affect social and organizational factors within the firm and beyond. The technical responses that characterize earlier effort are supplemented or replaced by fundamental transformations at various levels of socio-technical systems, from business models to the more challenging institutional level.

For example, end-of-pipe solutions are unlikely to have significant social or organizational implications within the firm. In contrast, sustainability reporting requires identifying and extracting appropriate information and responding to it in meaningful ways. Beyond the firm's boundaries, at the wider systems level, reporting also implies changes in institutional design: for example, changes in capital markets so that social and environmental metrics can be appropriately valued.

An important feature of the model is the idea of *broken arrows* — a not necessarily straight path and the marked shift in mindset that occurs between Operational Optimization and Systems Building.

The framework incorporates important dimensions in firms' progression toward sustainability that have emerged over the past 20 years. Empirical examples of firm activity are found in the first two contexts, Operational Optimization and Organizational Transformation, but many agree that a truly sustainable firm (i.e. in the context of Systems Building) does not yet exist. Firms do debate how to operate as a Systems Builder and experiment in that direction, so we have indications of how a Organizational Transformer might look.

using the model

Mapping the SOI landscape in this way provides a useful tool, for organizations and for discussion of innovation management and activity. Specific implications for innovation can be identified (Table 1). The boundaries

between the three contexts appear porous. That is, some activities, particularly those relating to product and process innovation, would not be out of place in any of the contexts. What distinguishes the contexts is, as Bos-Brouwers (2010b) points out, "purpose and direction": whether the firm focuses on efficiency or effectiveness, reducing harm or doing good.

How do firms enter the model? Firms start from different positions and with different objectives. There is not a "right place to start," but an audit of existing practices will help pinpoint gaps and identify "low-hanging fruit" (opportunities for quick wins) or areas where the firm can realize substantial ambitions. To move their firm upward and rightward on the sustainability model, managers may want to use Table 1 as a checklist for both benchmarking their activities and mapping a route consistent with their sustainability objectives. The next chapter expands on these activities.

Table 1

THE ACTIVITIES OF SOI

OPERATIONAL OPTIMIZATION	ORGANIZATIONAL TRANSFORMATION	SYSTEMS BUILDING
Collaborations and relationships • Co-operate and network externally to compensate for lack of resources or lack of expertise and to enhance legitimacy and social licence to operate. Collaborators may include regulators, suppliers and knowledge institutions • Collaborate internally and across functions to integrate SOI across the firm and enhance opportunities for new product success • Work with customers to identify their sustainability concerns (and thus opportunities for adding value) and to enhance legitimacy and the social licence to operate **Capacity and climate** • Exploit existing innovation capabilities to facilitate the adoption of incremental innovations • Empower the top team to set the direction of and climate for SOI and ensure clarity of the innovation purpose • Codify and formalize SOI targets and policies; integrate sustainability goals into existing technical specifications • Monitor performance against specific SOI criteria	**Systemic relationships** • New opportunities can be explored at the interfaces of previously unrelated industries • Collaborations become increasingly interdependent • New innovation platforms can be tested: e.g. reverse innovation, jugaad innovation and resource-constrained innovation **Capacity and climate** • Ensure that the top management team and line managers are seen as having a commitment to sustainability; communicate the values and goals of sustainability; set goals and targets that reach beyond operational and eco-efficiencies • Ensure reward systems and incentives reflect the focus on sustainability • Revisit and reframe the business model and modes of governance to acknowledge the firm's commitment to sustainability • Integrate sustainability metrics into financial reporting; adopt transparent sustainability reporting • Exploit organizational slack • Extend search activities into unfamiliar fields: use peripheral vision to search for weak signals • Unlearn outdated capabilities	**Apply a whole-systems focus to influence the redesign of institutions and infrastructures and the reconceptualization of the business purpose.** • Derive new value propositions from entire socio-technical and ecosystem value network to make a positive impact with an inclusive business • Engage in institutional dialogues to "change the rules of the game" • Reframe the purpose of the firm: suffuse and infuse all dimensions of TBL into the organization • Initiate, mobilize, lead and inspire systems change • Apply equal weight to all aspects of the TBL in organizational thinking and decision-making

OPERATIONAL OPTIMIZATION	ORGANIZATIONAL TRANSFORMATION	SYSTEMS BUILDING
Process innovation • Design for sustainability: Redesign existing processes through incremental innovation: e.g. use tools to support SOI by addressing single issues such as pollution control; modify and redesign processes to address resource use, waste and pollution • Use available tools such as environmental management systems and life cycle analysis to integrate sustainability into processes • Adopt sustainable supply chain management practices and ensure suppliers are operating sustainably **Product innovation** • Use design tools to redesign products to address sustainability considerations: e.g. dematerialization • Reduce materials' impacts and products' energy consumption • Design "green" from the outset: e.g. integrate recovery, reuse and disposal thinking early in the design process; set targets early • Ensure functionality is not compromised **Knowledge management** • Exploit existing knowledge management capabilities to identify and access relevant knowledge; reframe internal communications to a focus on sustainability; unlearn existing knowledge that contradicts the firm's sustainability principles • Fill competence gaps through training, targeted recruitment and the import of expertise; integrate diverse elements of TBL considerations across the firm by issuing guidelines and monitoring compliance	**Process innovation** • Adopt new process platforms such as closed-loop manufacturing and cradle-to-cradle innovation • Develop new networks into the wider social, economic, legislative systems and, particularly, into supply chains; develop long-term collaborative approaches with external partners • Start from a vision of the future and work backward, rather than moving forward from the present; set audacious goals even when the route may be unclear **Product innovation** • Adopt a servitization strategy: supplement or replace products with services • Search for product innovation ideas in new areas: e.g. use biomimicry and engage with bottom-of-the-pyramid customers • Be attentive to disruptive and systems-changing innovation happening elsewhere • Learn lessons from local firms and from new innovation platforms such as frugal innovation	

innovating for sustainability

In each context – Operational Optimization, Organizational Transformation and Systems Building – firms engage in specific innovation activities. This chapter describes these activities in detail in order to allow firms to benchmark their current actions and map a route forward.

The previous chapters presented a model describing three contexts of sustainability-oriented innovation: Operational Optimization, Organizational Transformation and Systems Building. In this chapter, we review firms' innovation activities in response to sustainability drivers at each context and expand on the list of practices just presented.

SOI in the context of operational optimization

For many firms, the first steps toward SOI stem from their activities to ensure compliance with environmental and social regulations. In this context, their innovation is either reactive or proactive. Reactive innovation refers to activities in response to obligations. Proactive innovation is characterized by a firm's initiative to go beyond regulation, e.g. by collaborating with the firm's immediate stakeholders.

The focus of an Operational Optimizer is predominantly internal: inward-looking, risk-reducing and efficiency-seeking. Innovative solutions seek to diminish unsustainable practices by focusing on resource efficiencies and incremental technological improvements to products and business processes. For example, a firm might begin by adopting stand-alone, "add-on" innovations, such as end-of-pipe technologies. Operational Optimization is enabled by conventional innovation and knowledge-management capabilities that are newly oriented toward sustainability.

The shift from a reactive to a proactive orientation usually occurs when the reactive position becomes uneconomic — for example, when add-on solutions incur costs greater than the costs of a process redesign (Alston & Roberts, 1999) or when firms view a sustainability orientation not as a risk but as an opportunity. Firms move from their previous ad hoc approach to a more formalized integrated strategy of innovation that instills sustainability more widely, both internally and by engaging with stakeholders. Firms look beyond their own boundaries to extend sustainability considerations into supply chain management and customer relations.

These are the practices that characterize Operational Optimizers.

COLLABORATIONS AND RELATIONSHIPS

Collaborations with diverse partners bridge knowledge gaps and exploit synergies:

1. Co-operate and network externally to compensate for lack of resources or lack of expertise and to enhance legitimacy and social licence to operate. Collaborators may include regulators, suppliers and knowledge institutions.
2. Collaborate internally and across functions to integrate SOI across the firm and enhance opportunities for new product success
3. Work with customers to identify their sustainability concerns (and thus opportunities for adding value) and to enhance legitimacy and social licence to operate

SOI is the integration of diverse and sometimes conflicting economic, environmental and social considerations. Firms may not have the requisite

in-house expertise regarding such matters as regulatory obligations, changes in raw materials, product redesign or life-cycle assessment methodologies. Collaborations and stakeholder relationships provide diverse and new sources of knowledge to support SOI. Sustainability-oriented innovators actively collaborate with internal and external stakeholders to identify useful and relevant knowledge.

1. Co-operate and network externally to compensate for lack of resources or lack of expertise and to enhance legitimacy and social licence to operate

Traditional innovation studies have pointed to firms' increasing co-operation with external sources of specialist knowledge, such as universities and lead users, as an important factor in their innovation performance (Chesborough, 2003; Von Hippel, 1986). Such collaborations reduce the complexity of SOI — even more so than in the development of conventional innovations (e.g. Ayuso et al., 2011; Petruzzelli et al., 2011). A shared commitment to sustainability considerations promotes collaboration.

Stakeholder collaboration describes diverse engagements both inside and outside the boundaries of the firm with, for example, regulators, value-chain associates, industrial or commercial customers, waste-disposal firms, recycling firms, competitors, trade associations, scientific institutions, trade unions, government agencies, lobby and special-interest groups, NGOs, the wider public and media. Each may contribute to SOI by sharing their knowledge.

For small- and medium-sized enterprises (SMEs), the stability and recurrent transactions of their network are key to improving their environmental performance (Biondi, Iraldo & Meredith, 2002).

In Practice

Network collaborations allow technological innovations to be applied to similar production processes and products. In the textiles sector, a small number of SMEs (including competitors, hence co-opetition) participating in a European Commission program invested in a single R&D project, sharing financial resources to buy a pilot plant for testing production processes. The circulation of know-how in these networks is a major facilitating factor in developing innovations. Adapted from Biondi et al. (2002).

Similarly, in the automotive industry, fuel-cell technology development has occurred in international networks, with firms strategically acquiring access to emerging competencies (Peters & Coles, 2006).

The knowledge component of these collaborations is particularly important. Because of the complexity of sustainability issues, firms need collaborators who can provide complementary knowledge-intensive competencies. Collaborations provide opportunities for learning about desirable sustainability solutions, discontinuous innovations and market opportunities (Könnölä, Carrillo-Hermosilla & Gonzalez, 2008). Collaboration with diverse actors also supports a company's social licence to operate.

2. Collaborate internally and across functions to integrate SOI across the firm and enhance opportunities for new product success

Internally, SOI can require working with different departments and functions, and the integration of internal and external expertise. These interactions and inter-functional communications lead to sharing of information across functions, transfer of practices and a culture of embedded sustainability. Collaborations tend to broaden as sustainability develops greater significance in the firm. For example, incremental, add-on innovations to address emissions are unlikely to require or result from extensive collaborations.

3. Work with customers to identify their sustainability concerns (and thus opportunities for adding value) and to enhance legitimacy and social licence to operate

Customer engagement provides a classic source of innovation opportunity in conventional innovation theory. Incorporating customers' sustainability concerns in the new-product development process is also a useful way to identify where to add value. Initially, this approach may involve simply assisting customers by responding to the "bureaucratic inconvenience" of compliance with regulation rather than responding to the sustainability agenda (Foster & Green, 2002). For example, the focal company might adopt "green" certification of its products and processes, thereby establishing its "green credentials" according to customer requirements — or the engagement may be deeper. User groups contribute to the technological development of the innovation and provide opportunities for diffusion and uptake, which can be particularly helpful when technologies lack market legitimacy (Hart & Sharma, 2004; Ornetzeder & Rohracher, 2006).

CAPACITY AND CLIMATE

1. Exploit existing innovation capabilities to facilitate adoption of incremental innovations
2. Empower the top team to set the direction of and climate for SOI and ensure clarity of the innovation purpose
3. Codify and formalize SOI targets and policies; integrate sustainability goals into existing technical specifications
4. Monitor performance against specific SOI criteria

1. Exploit existing innovation capabilities to facilitate adoption of incremental innovations

According to the traditional neo-classical economic model, the primary obligation of corporations is to maximize profits for shareholders. This view fits comfortably with the idea of Operational Optimization, particularly the notion that sustainability principles can be integrated into the firm's existing model without compromising product quality, performance and reliability. Thus, organizations that lack a pervasive culture of sustainability can exploit their existing capabilities for innovation by adopting relatively simple SOIs, such as technological add-on solutions.

Supportive climates are important for any innovation. These can involve senior management support, a sense of individual safety that encourages both participation and the contribution of new ideas, a clearly articulated vision and a clear task orientation or commitment (Anderson & West, 1998). The additional complexity of SOI makes a supportive environment

even more important. Because a previous systematic review (Bertels, Papania, & Papania, 2010) focused on embedding a culture of sustainability into the organization, we cover this area relatively briefly.

2. Empower the top team to set the direction of and climate for SOI and ensure clarity of the innovation purpose

The direction of and climate for SOI are set by the firm's top management team (TMT). They must communicate the need for and nature of sustainable goals, demonstrate and communicate commitment to SOI and embed SOI principles into the organizational strategy. TMT's role is key in showing employees the importance of sustainable objectives in relation to the organizational purpose (Lee, 2009; Petala, Wever, Dutilh & Brezet, 2010). Line workers, for example, are more receptive to sustainability considerations when the purpose is clear (Florida, Atlas & Cline, 2001).

3. Codify and formalize SOI targets and policies; integrate sustainability goals into existing technical specifications

To help deliver the firm's sustainability strategy, employees must understand the strategy and its importance in relation to other business activities. Important guides for SOI are the inclusion of sustainability criteria in firm documentation and the formalization of a firm's targets and policies.

The setting of goals for environmental improvement is closely associated with the adoption of environmentally conscious manufacturing practices. When sustainability targets and goals are integrated into existing technical specifications (Tingström, Swanström & Karlsson, 2006), SOI is embedded into the accepted way of operating.

4. Monitor performance against specific SOI criteria

Another way to embed SOI is through performance monitoring against explicit SOI criteria. Organizations thus measure, analyze and monitor their performance across the firm (through products, processes and organizational culture) in key dimensions of sustainability, and the results are reviewed to trigger improvements. Although performance monitoring is widely adopted and can be relatively easily integrated into existing systems, few companies use indicators that reach beyond operational and eco-efficiency aspects (Blum-Kusterer & Hussain, 2001). Scope exists for more sophisticated conceptualizations and for additional measures of sustainable performance.

KNOWLEDGE MANAGEMENT

At its core, SOI is an information challenge, making diverse knowledge and knowledge management essential. Operational Optimizer firms do the following:

1. Exploit existing knowledge management capabilities to identify and access relevant knowledge; reframe internal communications to a focus on sustainability; unlearn existing knowledge that contradicts the firm's sustainability principles
2. Fill competence gaps through training, targeted recruitment and the import of expertise; integrate diverse elements of TBL considerations across the firm by issuing guidelines and monitoring compliance

Operational Optimizers must source and integrate knowledge relating to materials and energy use, pollution and waste creation, and the product life cycle. This knowledge can come from multiple sources, such as databases that assess the life cycle impacts of materials. Firms with effective knowledge management processes are more likely to be sustainable innovators; knowledge management is a necessary sub-capability underlying sustainable innovation (Ayuso et al., 2011). Firms must also be prepared to recruit external expertise to assist in tasks such as life cycle analyses and materials selection when necessary.

1. Exploit existing knowledge management capabilities to identify and access relevant knowledge; reframe internal communications to focus on sustainability; unlearn existing knowledge that contradicts the firm's sustainability principles

Even at the beginning of the SOI journey, such as when adopting cleaner technologies, lack of the appropriate expertise can constrain firms' efforts. Knowledge management is important for conventional innovation, but must be re-thought for SOI. Organizations must reframe their internal communications, reconfigure their internal relations, initiate new conversations and "unlearn" and replace redundant knowledge, such as that relating to unsustainable product components (Bossink, 2007; Magnusson, Lindström & Berggren, 2003).

2. Fill competence gaps through training, targeted recruitment and the import of expertise; integrate diverse elements of TBL considerations across the firm by issuing and monitoring guidelines

Collaborations provide access to useful knowledge for SOI, but the newly acquired knowledge must then be appropriately managed within the firm (Ayuso et al., 2011). Firms must have sufficient absorptive capacity (Cohen & Levinthal, 1990) — that is, the capability to absorb and integrate new knowledge. For example, in a novel partnering arrangement, suppliers worked with an assembly plant together to implement new technology by integrating the suppliers' detailed knowledge of paint chemistry and environmental effects with the automakers' detailed knowledge of final product requirements and assembly plant operations (Geffen & Rothenberg, 2000).

The likelihood of successful SOI increases when more employees are specialized or have expertise in sustainability-related domains (Lee, 2009). Firm-level environmental capabilities can be enhanced in several ways: benchmarking and programs for reviewing products, services and operations; investments in employee training; cross-functional working; and inter- and intra-sectoral networking (Zwetsloot, 2001). For example, ABB bought a manufacturing firm that had the technical competences that it required but lacked (Sandström & Tingström, 2008). Firms can fill knowledge and competence gaps by hiring environmental specialists and by recruiting employees at all levels who have interests and skills in sustainability. Environmental training programs, especially for R&D staff, will support the firm's culture of SOI (Lee, 2009; Petruzzelli et al., 2011).

Environmental co-ordinators can further integrate sustainability thinking and behaviour (e.g. Pujari, Wright & Peattie, 2003) by integrating the diverse elements of

environmental new product development both across the firm and into the supply chain (e.g. by issuing guidelines and then monitoring compliance).

In the case of ABB's development of a dry capacitor, environmental specialists were not formally members of the project but their expertise was used continuously, particularly to access environmental data about materials and to support life cycle analysis (Sandström & Tingström, 2008).

PROCESS INNOVATION

Process innovations change the way an organization produces and delivers its product or services. These innovations take into account the social, environmental and technological characteristics of processes in an effort to reduce their overall impact.

1. Design for sustainability: redesign existing processes through incremental innovation: e.g. use tools to support SOI by addressing single issues such as pollution control; modify and redesign processes to address resource use, waste and pollution
2. Use available tools such as environmental management systems and life cycle analysis to integrate sustainability into processes
3. Adopt sustainable supply chain management practices and ensure suppliers are operating sustainably

1. Design for sustainability: Redesign existing processes through incremental innovation: e.g. use tools to support SOI by addressing single issues such as pollution control; modify and redesign processes to address resource use, waste and pollution

In the early 1990s Operational Optimizers focused on end-of-pipe technologies and then cleaner technology solutions. The two approaches are generally contrasted. End-of-pipe solutions target pollution control and are typically isolated initiatives aimed at capturing, redirecting or reducing emissions and polluting discharges. In contrast, cleaner technologies target pollution prevention by improving production efficiency through the adoption of new technologies that reduce pollution or minimize waste.

End-of-pipe solutions capture pollution and transfer it between media, whereas cleaner technologies use process changes to reduce polluting outputs. The latter are more environmentally valuable and effective. Thus, process-related SOIs can be either "add-on" or integrated technologies. End-of-pipe technologies are add-ons to existing processes or products, whereas, in cleaner technologies, the environmental characteristics are embedded and thus are part of the process or product. The latter also offer greater potential for cost savings.

Recently, as alternative forms of energy have become available, process innovations have sought to reduce energy input in the production process or replace fossil-fuel energy supplies either through self-generated or purchased renewable energy.

2. Use available tools such as environmental management systems and life cycle analysis to integrate sustainability into processes

Sustainability considerations are integrated into firm processes through the use of such tools as eco-design, environmental management systems and life cycle analysis. Many firms use these tools to integrate SOI into their organizational thinking and practice, often addressing both product and service considerations and process issues. This multitude of stylized approaches, frameworks and assistive tools provide systematic and structured support for identifying, reducing and eliminating the life cycle environmental impacts of products and services.

In Practice

Unilever developed the Brand Imprint tool to link directly to innovation. Its purpose is to help brands to effect both incremental and transformational changes in the way they source, formulate, manufacture, package and market products by analyzing the social and economic value the brand adds and the negative impacts it causes. Adapted from Petala et al. (2010).

The tools range in complexity from simple checklists concerning single issues (e.g. pollution control) to resource-intensive tools that aim for a more comprehensive assessment of impact, such as life cycle analyses. Typically, they benchmark eco-efficiency to determine resource-efficiency potentials: for example, the MIPS (**M**aterial **I**nput **P**er unit **S**ervice or output) tool (Lettenmeier, Rohn, Liedtke & Schmidt-Bleek, 2009) measures the material and energy inputs of a product throughout its life cycle. The more complex tools assist the company in more fully integrating sustainability into core business processes.

By 2007, the proliferation of sustainability assessment principles, strategies, actions and tools had led to confusion among managers about which approaches to choose (Waage, 2007). Today, the literature is still unclear on which strategy is appropriate for any firm in any particular context. Studies report on the variable use of tools and frameworks among firms. The tools result in TBL benefits (e.g. López-Pérez, Perez-Lopez & Rodriguez-Ariza, 2007) but may be constraining more radical innovation (e.g. Könnölä & Unruh, 2007).

We briefly emphasize two tools: environmental management systems and life cycle analyses. Environmental management systems (EMSs) are among the most commonly used environmental tools. An EMS is defined as a "formal system and database which integrates procedures and processes for training personnel, monitoring, summarizing and reporting of specialized environmental performance information to internal and external stakeholders" (Melnyk, Sroufe & Calantone, 2003: 332). EMSs provide a systematic way of addressing environmental impacts by developing, implementing, coordinating, monitoring and evaluating business processes and procedures. EMS schemes vary, but can include improvements in management processes, building employee awareness, systematically documenting procedures and targeted improvements to production processes. EMSs are a particularly important determinant of sustainability-oriented process but not product innovation.

Formally implemented with certification and informally implemented with uncertified adaptations, EMSs have

become the pre-eminent procedural tool for internal management (Könnölä & Unruh, 2007). However, they have been criticized for locking firms into exploiting their existing production processes rather than exploring more radical innovation opportunities.

Life cycle analysis (LCA) is also widely used for measuring environmental impacts and deciding on the development of new products and processes. LCA provides a clear picture of a product's impacts throughout its life, from extraction and refinement of materials to manufacturing, transport, use, maintenance and, ultimately, end-of-life disposal; and, in doing so, LCA highlights and evaluates opportunities for improvements. LCA identifies critical areas, making life cycle thinking core to the sustainable product development process. The two following cases illustrate the role of LCA in product development at Patagonia and at Michelin:

In Practice

Patagonia learned from an LCA that shirts made from regular cotton consume three times more petroleum in their lifetime than shirts made of synthetic fibre (due to the fertilizers used to grow the cotton and the extra effort needed to keep the garment clean). Recognizing that the extensive use of these chemicals harms water, soil and the health of farm workers, the company subsequently converted its sportswear lines to 100 per cent organic cotton, which requires fewer chemicals. Adapted from Ceres (2010).

In Practice

Michelin used an extensive LCA of tire production and learned that 86 per cent of tires' CO2 emissions result from the rolling phase — i.e. when the tire is being used. Thus, Michelin examined how rolling resistance could be reduced to obtain higher fuel efficiency and thus lower the cost of mobility, while also producing less exhaust. The company found these objectives could be achieved by partly replacing carbon black, which is used as reinforcement filler in tires, with silica. Although on the face of it a small modification, it was a risky project that took several years, the support of raw materials suppliers and R&D investment of almost €400 million. Adapted from OECD (2010).

Companies should perform an LCA for each portfolio of products or for specific products to determine the full scope of their sustainability impacts. This assessment should identify key environmental and social implications of the choice and sourcing of inputs, the manufacturing process itself and each product's use and disposal. Because LCA can be resource-intensive, many firms do not apply it across their full product ranges. One recommendation might be to apply LCA to new products or product modifications and to allow older products to become discontinued.

LCA has multiple variants (Kaval, 2011). Information and communication technologies allow for system-wide comparisons of environmental advantages and disadvantages (Foster & Green, 2002). LCA has also been standardized by ISO 14000 into four elements:

- Definition of the goal and scope: set the boundaries of the exercise
- Life cycle inventory analysis: quantify the relevant impacts (e.g. materials used, waste produced)
- Life cycle impact assessment: evaluate the values generated in analysis
- Life cycle interpretation: examine the results, draw conclusions and make recommendations

LCA extends the assessment of environmental impact beyond the boundaries of the firm (Buttol, Buonamici, Naldesi, Rinaldi, Zamagni & Masoni, 2012; Simon, Poole, Sweatman, Evans, Bhamra & McAloone, 2000). Other tools to support SOI similarly extend sustainability thinking beyond the boundary of the firm to include the firm's supply chain. Extending engagement into the supply chain can significantly improve the likelihood of success for sustainable new product development (Lee & Kim, 2011), as sustainable inputs enable sustainable output. Sustainable supply chain innovation can affect the end product and all processes.

3. Adopt sustainable supply chain management practices and ensure suppliers are operating sustainably

Sustainable supply chain management[4] (SSCM) can take a variety of forms and involve a variety of actors. For example, sharing information with suppliers can help designers and product developers to innovate when developing prototypes and new products (Lee & Kim, 2011; Pujari et al., 2003). This information exchange is especially valuable when supply-chain firms have different technological or environmental know-how (Lee & Kim, 2011).

Other activities might include sourcing sustainable materials from alternative suppliers or working with existing suppliers to provide sustainable materials; developing sustainability standards for the supply chain and then operationalizing them through a supplier code of conduct; providing environmental design specification to suppliers; co-operating with suppliers to work toward environmental objectives; performing environmental audits for suppliers' internal management; requiring suppliers' ISO 14000/ISO 26000 certification; co-operating with customers on environmental objectives (Pujari et al., 2003; Zhu, Sarkis, & Lai, 2011).

These tools build environmental sustainability into products and sometimes also into services. However, tools or even conceptual frameworks, for building social sustainability into products and services are less common.[5] Businesses, policy makers and researchers need to develop a better understanding of how to maximize social value into environmental and other business process tools.

[4] A more common term is *green supply chain management*, which indicates the subordination of social to environmental considerations.
[5] However, see The (Social) Innovator's toolkit: http://socialinnovation.ash.harvard.edu/innovators-toolkit.

PRODUCT INNOVATION

Process innovations change the way the organization produces and delivers its products or services and might, for example, involve the introduction of new elements into production or service operations. Product innovations change what the organization offers to the outside world. In effect, this is what the customer sees (Bessant, Lamming, Noke & Phillips, 2005). These innovations consider the role of social, environmental and technological characteristics in reducing the overall impact of products and services. They:

1. Use design tools to redesign products to address sustainability considerations: e.g. dematerialization
2. Reduce materials' impacts and products' energy consumption
3. Design "green" from the outset: e.g. integrate recovery, reuse and disposal thinking early in the design process; set targets early
4. Ensure functionality is not compromised

To comply with regulations, enhance corporate environmental image, exploit market opportunities and respond to internal pressures, sustainable product innovation strategies for Operational Optimizers attend to materials, energy and pollution (Dangelico & Pujari, 2010).

1. Use design tools to redesign products to address sustainability considerations: e.g. dematerialization

A variety of product development support tools exist, as charted by Maxwell and Van De Vorst (2003). Design tools enable users to evaluate sustainable materials and sustainable design alternatives and relate them to financial incentives, environmental regulations and the demands of clients (Bossink, 2002). Consequently, many firms adopt sustainability-oriented design tools (SODTs), integrating them into existing processes to ensure environmental and social considerations become routine. No "best" set of design principles exists and firms need to make decisions based on their own particular circumstances. These SOI tools can be integrated into existing quality management systems, for example, by establishing sustainability milestones, roadmaps and checkpoints or by integrating sustainability as an explicit goal in the design process.

Another tool, the sustainable product and service development (SPSD) method proposed by Maxwell and Van De Vorst (2003), tries to incorporate TBL principles into a holistic perspective on the product life cycle. It assesses the function to be provided by the product or service and the optimal sustainable way of providing that function.

Tools focus on different sustainability issues and at different scales. Elements considered by these tools include the following:

- The use, re-use, recycling and disposal of spent products, including the minimization of their waste legacy
- Designing for remanufacturing and/or disassembly (as in the cradle-to-cradle design model)
- Changing product packaging (minimizing packaging, using alternative and biodegradable materials)
- Eco-labelling

- Reducing energy and chemical use and intensity
- Extending product life
- Dematerializing products by conserving materials and minimizing the use of virgin and non-renewable inputs
- Replacing products with services (servitization)

Firms can adopt these approaches individually, perhaps tackling more pressing sustainability challenges first. However, the piecemeal approach has been superseded by more holistic redesign based on life cycle thinking (Ceres, 2010; Noci & Verganti, 1999; Shrivastava & Hart, 1995).

Table 2

BREZET AND HEMEL'S (1997) SUSTAINABLE DESIGN STRATEGIES AS ADAPTED BY (COLBY, 2011)

SUSTAINABLE DESIGN STRATEGY	SUB STRATEGIES
Strategy 0: **New Concept Development** Address product system specifications before the product design is finalized. The focus is not on a physical product but on the function of a product system and its ability to fulfill a need.	**Dematerialization** – replace a material product with an immaterial substitute that fulfills the same need **Shared use of the product** – meet needs by using fewer products **Integration of functions** – use one object to answer numerous needs **Functional optimization** – avoid superfluous components
Strategy 1: **Selection of Low-Impact Materials** Choose the least harmful input materials. The use of lower-impact inputs is contingent on the life cycle of the product because of the need for materials to be context-relevant.	**Cleaner materials** – avoid the use of materials that cause hazardous emissions during production or when disposed of **Renewable materials** – replenish material sources naturally **Recycled materials** – use materials that have previously comprised other products **Recyclable materials** – use materials that can be repurposed as other materials; most effective when recycling collection is offered
Strategy 2: **Reduction of Material Usage** Use the least amount of material possible by proposing lean yet strong product designs.	**Reduction of weight** – reduce the environmental impacts associated with distribution **Reduction in (transport) volume** – decrease the need for transportation
Strategy 3: **Optimization of Production Techniques** Adopt production techniques that minimize the use of auxiliary materials and minimize energy use.	**Alternative production techniques** – create new techniques to address specific production needs **Fewer production steps** – simplify production processes to be less harmful **Lower/cleaner energy consumption** – reduce the environmental impact of the production process **Less production waste** – maximize production efficiency to minimize waste and emissions **Fewer cleaner production consumables** – minimize the use of input materials
Strategy 4: **Optimization of the Distribution System** Ensure that the product is transported to the retailer from the factory in the most ecologically efficient manner possible.	**Less/cleaner/reusable packaging** – minimize the impacts associated with product packaging **Energy-efficient transport mode** – use the most efficient modes of transportation **Energy-efficient logistics** – optimize logistics related to loading and distribution

SUSTAINABLE DESIGN STRATEGY	SUB STRATEGIES
Strategy 5: **Reduction of Impact During Use** Reduce the consumables (such as energy, water, detergent, batteries, etc.) associated with the use of a product.	**Lower energy consumption** – evaluate the efficiency of energy-related components **Cleaner energy sources** – choose renewable energy, when possible **Fewer consumables needed** – make products as autonomous as possible **Cleaner consumables** – chose benign ingredients **Reduce wastage of energy and other consumables** – encourage efficient usage of the product
Strategy 6: **Optimization of Initial Lifetime** Aim to make the product useful for the longest possible time, by prolonging the technical, aesthetic and initial lifetimes of a product.	**Reliability and durability** – make a good quality product **Easier maintenance and repair** – ensure necessary maintenance is completed on time **Modular product structure** – revitalize broken or unwanted products **Classic design** – avoid trendy designs **Stronger product–user relation** – encourage users to properly care for products, which will lead to respect and proper product maintenance
Strategy 7: **Optimization of End-of-life System** Require proper waste-management and end-of-life treatments. Material cycles should be closed when possible or otherwise disposed of appropriately.	**Reuse of product** – encourage retaining products in their original forms to achieve greater environmental merit **Remanufacturing/refurbishing** – reuse subassemblies in new manufacturing processes **Recycling of materials** – build a take-back and recycling infrastructure to ensure a high percentage of recycling **Safer incineration** – promote thermal recycling from incinerated products, which can be beneficial when done safely

2. Reduce materials' impacts and products' energy consumption

Firms can reduce materials' impacts by incorporating recycled materials or replacing harmful components with biodegradable alternatives; using materials lists to identify substances or components that should not be used; and integrating recovery, reuse and disposal thinking early in the design process. Energy impacts can be moderated through the technological redesign of products so that they consume less energy and by reducing energy consumption on-site (e.g. through the use of energy efficiency and/or renewable energy in production).

3. Design "green" from the outset: e.g. integrate recovery, reuse and disposal thinking early in the design process; set targets early

By designing green from the outset rather than redesigning green (Alston & Roberts, 1999), and by setting environmental and technical targets early, design teams are obliged to take sustainability into account in the early stages of product development, avoiding costly remedial action. Operational Optimizers set targets likely to be achieved through incremental innovations (e.g. reducing the percentage of harmful emissions or increasing the percentage of renewable materials as components).

4. Ensure functionality is not compromised

Developers should ensure that sustainable products function as well as their non-sustainable alternatives (Stafford & Hartman, 2001). A product with a sustainable profile must be just as reliable, safe, convenient, usable and aesthetically attractive as other products. However, some firms in the context of Organizational Transformation have replaced this principle, for certain markets, with the idea that products need only be good enough.

SUMMARY

Many activities characterize SOI in the context of Operational Optimization, reflecting the range of the business response to the sustainability challenge.

Operational Optimization can be pursued by modifying existing innovation capabilities, pathways, skills, project management arrangements, etc. (Seebode et al., 2012). Indeed, few studies focus on reassessing the core constructs of the innovation process (search, select, implement and capture) in the context of sustainability. Recognizably conventional processes appear to be in play, but are adapted and extended through the use of sustainability-oriented tools and techniques.

By integrating sustainability principles into existing quality and process management systems, firms can make sustainability a primary consideration. For example, in a study of the integration of environmental considerations into technological innovation processes in the UK chemical industry, most firms set up systems for environmentally inclusive R&D project management (Foster & Green, 2002). Although the processes were integrative, they tended to be compliance-focused and mostly relied on checklists.

These approaches are often called eco-efficient and provide guidance on addressing environmental issues from a firm and product/process perspective.

These approaches make an important contribution at the firm-level, but their impact is limited and, on their own, they are insufficient to address the sustainability challenge. For example, any gains from eco-efficiency may be offset by the “rebound effect” (Carrillo-Hermosilla et al., 2010); in other words, increases in environmental efficiency may be erased by subsequent growth.

The key to sustainability is not optimizing isolated parts of a system but rather enhancing the resilience of the whole (socio-ecological) system. SOI beyond Operational Optimization reflects this systemic view, the pursuit of effectiveness over efficiency. To move from Operational Optimization, firms need to extend beyond risk reduction, cost-cutting and the notion of doing less harm. Resilience refers to the ability of systems to absorb disturbance and reorganize while both undergoing change and continuing to retain essentially the same function, structure, identity and feedback (Westley et al., 2011).

Such a paradigm shift in the organization and management of the enterprise is challenging. Some firms are beginning to navigate a path in which they experiment with and explore the implications of new

behaviours, practices and mindsets (Baya & Gruman, 2011; Dunphy, Griffiths & Benn, 2003; Low, Lamvik, & Myklebust, 2001; Mani, Lyons, & Sriram, 2010; McDonough & Braungart, 2002;).

SOI in the context of organizational transformation

While Operational Optimizers aim to do more with less, firms in Organizational Transformation pursue a different objective, the most ambitious conceptualization of which is the "net positive impact" firm.

These firms must identify and work with new types of partners, build external linkages to motivate and inspire systemic change, address the social dimension of sustainability and reframe and redefine the purpose of business in society as part of wider social and environmental ecosystems.

Organizations in this space experiment with innovative practices characterized by the following activities:

- Transforming relationships and interactions between industry and diverse stakeholders
- Transforming consumer behaviour
- Delivering products and services to under-served populations
- Reframing the purpose of business in society

This transition has frequently been discussed in terms of the Schumpeterian notion of creative destruction, the continuous reconfiguring of organizations in response to change (e.g. Stafford & Hartman, 2001). Firms find this to be a challenging space to occupy, and many change agents meet with resistance within the firm and from established firms, the marketplace and other stakeholders.

Navigating the transition can be particularly difficult for incumbent firms that may be constrained by legacy systems and may find their core competences becoming core rigidities (Leonard-Barton, 1992). Existing systems' entrenched behaviours and practices act as barriers. Firms may find help to negotiate this space through novel collaborations (e.g. with environmental NGOs) and by extending the firm's non-technological competences (e.g. the ability to lobby or to find alternative routes to market).

Walden Paddlers is an interesting case of a start-up that, guided by principles of sustainability, was able to achieve its goals because it had the opportunity to design relationships and principles from scratch.

In Practice

Success, in the case of Walden Paddlers, was accredited to the principal's sustainability vision and capacity to mobilize resources in the network organization, as a result of informal communications, considerable selling of ideas and continuous learning and adaptability as new information emerged. Further, Walden Paddlers adopted an alternative mode of organization, the virtual corporation or network, in which the entire value chain was conceived as a source of opportunity. Adapted from Larson (2000).

In the Organizational Transformation context, firms explore ways of shifting the organizational mindset from "doing less harm" to "creating shared value" and "delivering wider benefits for society." Firms operating in this context also increasingly focus, either incrementally or systemically, on the social dimension of sustainability, which emphasizes the need to address unmet human and societal needs. This is a shaping logic that goes beyond an internal, operational focus on greening to a more external, strategic focus on sustainable development (Hart, 1997).

Innovation in the context of Organizational Transformation involves small-scale explorations and experimentation not only in products and services but also in social and organizational aspects, which may lead to new business models. Such innovation is more challenging but offers significantly higher potential to achieve more ambitious sustainability-oriented goals than the gradual incrementalism characteristic of Operational Optimization.

In this context, an awkward juxtaposition can occur between "good business economics of cost savings through environmental investments" and "strategic re-orientation of the firm around sustainability concerns," in which the firm takes on new responsibilities regarding environmental and social development. Many firms in this category experiment within an existing institutional framework at, for example, the level of the product or the strategic business unit (SBU).

SYSTEMIC RELATIONSHIPS

Sustainability develops greater significance in the firm, making new types and degrees of collaboration evident.

1. New opportunities can be explored at the interfaces of previously unrelated industries
2. Collaborations become increasingly interdependent
3. New innovation platforms can be tested: e.g. reverse innovation, jugaad innovation and resource-constrained innovation

1. New opportunities can be explored at the interfaces of previously unrelated industries

The Kalundborg industrial symbiosis project is a powerful illustration of this type of interdependence. Eight firms co-operated to convert their environmental problems into business opportunities, whereby one company's waste material or energy became another's resources. By pooling material resources, the Kalundborg companies derived synergistic environmental and economic benefits (Birkin, Polesie & Lewis, 2009).

In a Swedish multi-sectoral initiative, the Landskrona industrial symbiosis program brought more than 20 firms and three public organizations together to search for novel solutions to sustainability challenges. The initiative focused on the following:

- Defining the problem
- Searching for benefits at inter-sectoral interfaces
- Enhancing learning through inter-organizational collaboration

This facilitated exploration paved the way for innovations typified by the discovery of opportunities at the interfaces of previously unrelated industries. In one case, wastewater from car glass manufacturing replaced the drinking-quality water that had previously been used in the wet scrubber used for removing

volatile organic compounds (VOCs) from a printing company's flue gases. In another case, relatively large amounts of glass waste generated by one company were used in the construction industry. The innovations led to environmental and economic benefits (Mirata & Emtairah, 2005).

Both industrial symbiosis projects powerfully illustrate the importance of the systemic view. Individually, firms in the projects were unsustainable, but as a system, they are sustainable. Firms can become part of sustainable systems without having to become sustainable independent of those systems[6], which raises important questions about whether individual firms can be sustainable within unsustainable systems; this question demarcates the frontier of current thinking and practice.

2. Collaborations become increasingly interdependent

In Organizational Transformation, firms redesign collaborations and engage with more diverse collaborators and with collaborators who previously would have been dismissed, including competitors and lobby groups (Dangelico & Pujari, 2010). Firms on their own have limited impact on sustainability challenges, which require systems solutions. Therefore, the formal and informal institutions of society need to come together, and firms, government, scientific institutes, NGOs and individuals need to participate in open experimentation (Loorbach, Van Bakel, Whiteman & Rotmans, 2010).

In the base metals industry, radical innovations are rarely implemented (despite their availability) because of technologically and socially embedded production systems — the locked-in effect. A solution could be to develop and extend inter-firm knowledge networks, which are useful for knowledge cross-fertilization, especially at the pre-competitive stage. Such networks should include connections with public R&D facilities, such as universities and technological institutes (Moors & Vergragt, 2002).

In the context of Organizational Transformation, collaborations can be complex. For example, tensions may emerge with a hostile NGO. Yet, NGOs may view industry as culpable while working collaboratively with business on innovative remedial or development programs, such as in the following example:

In Practice

Greenpeace worked with the German firm Foron Household Appliances to challenge established practices and propose an alternative in the manufacture and use of harmful chlorofluorocarbon (CFC) refrigerants. Greenpeace acted as a bridge, both by establishing links with mavericks, key market players and lead adopters and by linking into coalitions of supportive market players and stakeholders. Adapted from Stafford and Hartman (2001).

integrating collaborators sets the context for new product development (NPD) (Ornetzeder & Rohracher, 2006).

[6] The authors are grateful to Pam Laughland for this observation.

In Practice

In the development of the Tata Nano, the early integration of suppliers into the NPD process facilitated their input into component design, led to substantially lower costs and helped eliminate unnecessary frills while incorporating features valued by mass markets.[7] Adapted from Ray and Ray (2011).

The contribution of long-term collaboration between NGOs and companies to enable sustainable business practices is widely recognized.

In Practice

The conservation group World Wildlife Foundation (WWF) has adopted a series of collaborative and challenging partnerships with business. It provides companies insights into sustainability challenges and approaches, and helps create stakeholder engagement opportunities to support business becoming more resilient. It works with individual companies and across industry sectors, bringing together consumer groups, policy makers and investors to help drive systemic change. WWF's business partnerships include HSBC, Marks and Spencer, Unilever, Lafarge, Nokia, Coca-Cola, Barclays, BT, Vodaphone, Tetra Pak, SABMiller and IKEA. Adapted from Bendell (2000); Elkington (1998); and Wymer & Samu (2003).

3. New innovation platforms can be tested: e.g. reverse innovation, jugaad innovation and resource-constrained innovation

The principle of co-operation is greatly extended by firms experimenting with sustainable innovation in bottom-of-the-pyramid (i.e. low socioeconomic) markets. The value of co-operation is recognized by exponents of "reverse innovation" (a trickle-up effect, where innovations are first used in developing countries and then applied in developed countries) and "frugal" or resource-constrained innovation (a strategy whereby resource inputs are minimized, thereby reducing the end product's cost without loss of quality). The latter approach is also referred to as "jugaad innovation," from a Hindi word that translates roughly as "an innovation fix," referring to harnessing ingenuity to locate opportunities and improvise simple solutions (Radjou et al., 2012). See Appendix 6 for examples and Appendix 3 for definitions.

These novel collaborations are not well understood, particularly regarding an organization's place in systems-level co-evolution of a sustainable society (Loorbach et al., 2010). However, co-operating with environmentally neutral stakeholders or "naysayers" may constrain firms in achieving their sustainability objectives (Wagner, 2007), and firms may need to create new networks of relationships of willing players outside of established vested interests (Klein Woolthuis, 2010).

[7] The Tata Nano has been critiqued by some environmental NGOs for its lack of green credentials. However, by making available a car to people for whom cars were previously not affordable, the Nano arguably addresses the social equity dimension of sustainability. The case illustrates the frequent difficulty reconciling the three pillars of the Triple Bottom Line.

CAPACITY AND CLIMATE

Organizational Transformation requires that an SOI culture be developed and embedded through the entire organization. Sustainability must not be regarded as an add-on.

1. Ensure that the top management team and line managers are seen as having a commitment to sustainability; communicate the values and goals of sustainability; set goals and targets that reach beyond operational and eco-efficiencies
2. Ensure reward systems and incentives reflect the focus on sustainability
3. Revisit and reframe the business model and modes of governance to acknowledge the firm's commitment to sustainability
4. Integrate sustainability metrics into financial reporting; adopt transparent sustainability reporting
5. Exploit organizational slack
6. Extend search activities into unfamiliar fields: use *peripheral vision* to search for *weak signals*
7. Unlearn outdated capabilities

1. Ensure that the top management team and line managers are seen as having a commitment to sustainability; communicate the values and goals of sustainability; set goals and targets that reach beyond operational and eco-efficiencies

Leadership and communication are important components in establishing an appropriate climate. For example, at 3M, management's call for action was reinforced by meetings on implementation in each business unit or staff group. Company publications provided detail on the program, including examples of successful projects. 3M also relied on other communications tools, including internal television programs and the 3M intranet (Reed, 2002). Goals can vary in the extent of the ambition they articulate. Interface, for example, has set itself the goal of having zero impact by the year 2020 (Arratia, 2010). Such ambitious goals will stimulate qualitatively different and more radical thinking than incremental targets such as "reduce waste by 10 per cent."

Because line managers are a principal locus of contact with employees, they have an important role in inculcating and motivating an SOI culture, which includes the following activities:

- Encouraging environmental communication — using a democratic, participatory approach to encourage communication from employees
- Encouraging environmental competence building — allocating the appropriate time and resources
- Recognizing and rewarding positive environmental actions — using daily praise and awards to reinforce environmental successes and problem-solving
- Managing environmental goals and responsibilities and sharing them with employees
- Supporting environmental innovation — being open to new environmental ideas and encouraging employees to experiment to find solutions to environmental problems (Ramus, 2001)

2. Ensure reward systems and incentives reflect the focus on sustainability

SOI cultures can be built both from the top-down — for example, when senior management embed

sustainability goals and objectives in strategic and operational plans — and from the bottom up — for example, by being alert and responsive to and rewarding employees' SOI ideas and initiatives (Florida et al., 2001; Haanes et al., 2011). So, for sustainability to be strategically embedded, reward systems and incentives need to reflect the focus on sustainability. Some firms are more developed in this sphere than others:

In Practice

In a US study of 41 Fortune 200 companies, only about one-quarter of firms had incentives for environmental performance that extended to managers outside of the environmental function. Intel links individual compensation to environmental performance, funds innovative environmental projects and rewards employees who deliver significant sustainable impact. Sixty per cent of the remuneration of the CEO of Florida Ice & Farm is tied to performance on triple bottom line indicators. Adapted from Baya and Gruman (2011); Lent and Wells (1992).

3. Revisit and reframe the business model and modes of governance to acknowledge the firm's commitment to sustainability

Typically, contemporary business models are inappropriately conceived to deliver sustainable businesses. As a result, Organizational Transformation innovators revisit and reframe their business model. A novel paradigm has emerged in recent years: a business that attends equally to social, economic and environmental considerations (Bertens & Statema, 2011; Esslinger, 2011; Stubbs & Cocklin, 2008).

This model of the sustainable business remains unclear and, for Birkin et al. (2009) at least, no business claims to be fully realizing or implementing a business model for sustainable development. Nevertheless, progressive firms are experimenting in this area (OECD, 2010), as typified by the following emergent characteristics:

- Drawing on TBL considerations in defining its purpose
- Using a TBL approach in measuring performance
- Considering the needs of all stakeholders rather than just those who hold shares
- Regarding stakeholder engagement and collaboration as necessary
- Treating nature as a stakeholder
- Driving the cultural and structural changes necessary to implement sustainability through leaders or champions
- Engaging both a systems-level and a firm-level perspective (Stubbs & Cocklin, 2008)

Some firms are experimenting with new modes of governance that explicitly integrate sustainability. In the United States, a new legal form, the B Corporation,[8] has recently emerged to legally oblige committed firms to deliver societal benefits. B Corporations address two critical problems:

- Current corporate law makes it difficult for businesses to consider the interests of employees, the community and the environment when making decisions.
- The lack of transparent standards makes it difficult to distinguish between a good company and good marketing.

[8] See http://www.bcorporation.net/

4. Integrate sustainability metrics into financial reporting; adopt transparent sustainability reporting

Efforts toward developing a globally accepted standard of integrated reporting are being made across financial, environmental and social communities. In some countries, such as France, governments are beginning to make integrated reporting mandatory. Transparent sustainability reporting is being increasingly adopted by Organizational Transformation firms.

Some of this reporting does not require radical change to current business processes. However, much sustainability information is non-financial and needs to be converted into financial metrics, which are the main standard for evaluating organizational activity. Whether this conversion is feasible remains to be seen. In spite of the progress made, existing metrics do not cover the whole landscape of sustainability, omitting such areas as ecological degradation and social impact. Firms are experimenting with new modes of sustainability performance measurement, such as measures that can directly relate corporate environmental performance to the marketplace, revenues, customer satisfaction and upstream environmental impacts (Lent & Wells, 1992).

Multiple schemes have sought to establish common frameworks for reporting sustainability progress. These include the Global Reporting Initiative,[9] the International Integrated Reporting Committee,[10] the Carbon Disclosure Project[11] and the Dow Jones Sustainability Index.[12] Other organizations also are developing integrated TBL reporting guidelines (Kaval, 2011).

In Practice

In 2007, Nike created its Considered Apparel Index to score the environmental attributes of its apparel. In 2010, it was upgraded it to a web interface, to enable earlier designer and supplier involvement and firm access to performance data. Dow Chemical developed the Eco-Compass to assess innovations environmentally by plotting product functionality, material intensity, energy intensity, toxicity and resource conservation against two economic indicators: economic value created and security of the business position. Other Dow tools include the Sustainable Chemistry Index, which focuses on critical aspects of sustainability through the company's value chain, including renewable/recycled content, resource management, life cycle benefit, manufacturing efficiency, social need, manufacturing/transportation, product application and public policy/end of life. Adapted from Baya and Gruman (2011) and Dow Chemical Company (2012).[13]

A small but growing number of firms are publishing such integrated reports (EYGM, 2012).

Integrating measures with other organizational indicators helps to embed the sustainability mindset internally and to legitimize the firm externally. The reporting of these measures may take several forms, including social impact reports, environmental impact

[9] See www.globalreporting.org
[10] See http://www.theiirc.org/
[11] See https://www.cdproject.net
[12] See www.sustainability-index.com
[13] See http://www.dow.com/sustainability/goals/chemistry.htm

reports or as social and environmental indicators reported alongside the financial indicators in an annual report.

In Practice

Bendigo Bank does not produce a separate triple bottom line report as it believes that TBL reporting is a natural outcome of its business rather than an imposed structure. Its annual report details the progress and outcomes of the community engagement initiatives. Adapted from Stubbs and Cocklin (2008: 114).

Some sustainability reporting has been criticized for bias and self-laudatory "greenwashing" (Bos-Brouwers, 2010b), but limited evidence suggests that firms that commit to transparent and integrated sustainability reporting have better sustainability performance (Sardinha, Reijnders & Antunes, 2011). Embedding sustainability metrics with financial reporting integrates sustainability as a core concern for organizations' chief financial officers (CFOs), though a globally accepted standard for peer-to-peer and industry benchmarking remains elusive.

In Practice

The German sportswear company Puma is leading the way in transparency and disclosure of its external costs to society. It measures, evaluates and publishes data on its carbon emissions, freshwater usage, pollution and waste. The unique aspect of this exercise is that Puma has measured and monetized these impacts, calculating them along its entire supply chain. It has effectively created the world's first environmental profit-and-loss statement. Although Puma disclosed an estimated €145 million (US$182 million) in such externalities for 2010, the revelation was far from the public relations disaster that some had predicted. The firm is now using what it learned to engage its raw materials and manufacturing supply chain (which is where almost 95 per cent of these externalities arise) to improve its environmental performance. Source: Sukhdev (2012: 27).

5. Exploit organizational slack

Organizational slack refers to organizational resources in excess of the minimum necessary to produce a given level of organizational output (Nohria & Gulati, 1996). Ironically, despite the implied waste associated with this concept, firms may use slack to build SOI cultures. Slack can enable the following benefits:

- Market research through environmental surveys
- Speculative market testing of eco-labelling products

- Experimenting with more environmentally sound process innovation
- Speculative development of greener products (Bowen, 2002)

6. Extend search activities into unfamiliar fields: use peripheral vision to search for weak signals

Organizational Transformation firms extend their search activities into unfamiliar fields to search for indications of future sustainability concerns. Metaphors such as "using peripheral vision" or "searching for weak signals" emphasize that such searching extends beyond conventional market intelligence activities.

Weak signals, which are precursors to significant trends and change mechanisms, emanate from a diversity of sources, including community action groups, social entrepreneurs, lobbyists and activists (Mulgan, Tucker, Ali & Sanders, 2007). Hart and Sharma (2004) propose a similar concept, "radical transactiveness," a dynamic capability which seeks to systematically identify, explore and integrate the views of stakeholders on the "fringe" or in the "smart mob" specifically in order to manage disruptive change and create competitive imagination.

Firms need to be alert to, pick up and use such weak signals (Aschehoug, Boks & Støren, 2012; Holmes & Smart, 2009; Joshi, 2010) by investing in the absorptive capacity of the firm (Cohen & Levinthal, 1990), reaching out and bridging new communities of stakeholders (Hollander, 2003) and through entrepreneurial "bricolage" — in other words, creatively using scarce resources (Halme, Lindeman & Linna, 2012).

In a study of pioneering technological innovation directed to low-income markets, entrepreneurial bricoleurs acting at the peripheral edges of the organization were able to pick up signals in the potential market through their membership of community organizations (Halme et al., 2012). They then built new networks and influenced key stakeholders to mobilize resources to promote pro-poor business models. Such "institutional entrepreneurs" act at all levels, both inside and outside the organization, helping to build trust, broker solutions, secure resources and promote change. They create opportunities and dissipate resistance while building capacity, momentum and resilience of new approaches.

7. Unlearn outdated capabilities

For Organizational Transformation, firms must collaborate with and learn from diverse stakeholders. Firms dealing with bottom-of-the-pyramid markets and innovating in resource-constrained environments may find that their R&D processes, which are accustomed to working with large resource inputs, become a core rigidity. Firms may need to unlearn outdated capabilities and, instead, draw on local talent pools to develop and implement the appropriate product designs and help reduce costs (Ray & Ray, 2010). In the case study of the development of the so-called people's car, the Tata Nano (see page 39), Tata mined suppliers for innovative ideas for reducing the costs of design and manufacturing by leveraging and exchanging knowledge (Ray & Ray, 2011).

PROCESS INNOVATION

A number of categories of activity, such as process innovation, span the different contexts of SOI. Although the labels may be common, the activity content of the categories differs, reflecting the shift from a wholly economic orientation to greater privileging of the dimensions of the Triple Bottom Line.

1. Adopt new process platforms such as closed-loop manufacturing and cradle-to-cradle innovation
2. Develop new networks into the wider social, economic, legislative systems and, particularly, into supply chains; develop long-term collaborative approaches with external partners
3. Start from a vision of the future and work backward, rather than moving forward from the present; set audacious goals even when the route may be unclear

1. Adopt new process platforms such as closed-loop manufacturing and cradle-to-cradle innovation

Firms innovating in the Organizational Transformation space close the loop in their processes. This bio-inspired approach seeks to recover waste in production processes (and disposal) and turn it into new resources for production: it is exemplified in cradle-to-cradle innovation (McDonough & Braungart, 2002), closed-loop production systems (Machiba, 2010) and the circular economy (Geng, Sarkis & Xue, 2012). The circular economy, for example, describes an industrial economy that is restorative and eliminates waste. It comprises two types of material flow: biological nutrients, which are designed to re-enter the biosphere safely, and technical nutrients (non-biological materials), which are designed to circulate at high quality permitting re-use and so preserving or enhancing their economic value and minimizing waste (McDonough & Braungart, 2002).

Cradle-to-cradle and circular economy models challengethe notion of a linear supply chain. Products are designed for disassembly: they can be returned to manufacturers once their useful life is over to be reprocessed and recycled into new products. They are part of a supply system. The manufacturer takes on the responsibility for the product at the end of its useful life and so is inspired to design products with the core considerations of disassembly and reuse. One key to successful cradle-to-cradle or closed-loop innovation is to design out components that could be harmful to the biosphere (Birkin et al., 2009).

In Practice

"At the end of their life cycle, all types of products we produce are reusable in our production processes for future uses: they can be removed from the wall or flooring, cleaned and used again in production processes, giving life to new products" (Dangelico & Pujari, 2010: 478).

According to the originators of the concept (McDonough & Braungart, 2002), cradle-to-cradle innovation can be achieved through the following activities:

- Signalling intentions: committing to the new paradigm rather than continuing to pursue incremental improvement
- Restoring: striving for good growth rather than just economic growth

- Being prepared to innovate further: perfecting (not optimizing) the existing product; being prepared to listen to and to "feed-forward" as opposed to providing feedback — notice the signals emerging from outside the company
- Understanding and preparing for the learning curve: harnessing the need to be adaptable and flexible to allow room for growing in a new way
- Exerting intergenerational responsibility

One example of these principles is Terracycle,[14] a company whose purpose is to eliminate waste by providing recycling systems for previously non-recyclable or hard-to-recycle waste and converting these waste products into products.

Are these utopian ideals? Certainly they are challenging and although the principles can be applied at a product level, they work best when supported by the whole company. While only a few firms are actively pursuing this approach, the numbers are increasing and include Dutch carpet maker Desso; Van Gansewinkel, waste-management and nutrient-providing company; and Orangebox, a Welsh office furniture company (McDonough & Braungart, 2002). The following cases illustrate some of the associated challenges and benefits.

In Practice

The CEO of carpet manufacturer Desso, Stef Kranendijk, determined to make sustainability a critical differentiating factor in the eyes of customers. This strategy was to be underpinned by a cradle-to-cradle orientation. Desso had already implemented several sustainable initiatives, such as reducing energy use, but these had been largely cost-driven, not sustainability-driven. Embracing the cradle-to-cradle approach involved significantly larger commitments than Desso's previous sustainability initiatives. For example, the cradle-to-cradle strategy required producing easy-to-disassemble goods made of non-hazardous raw materials. Most raw materials being used across the industry at the time, however, were not even close to satisfying these strict criteria. The company needed to rigorously analyze all its raw materials and discard those that did not meet the criteria. Doing so involved significant costs and a radical redesign and re-conceptualization of product development and manufacturing. Adapted from Ioannou and Ody-Brasier (2011: 5).

[14] See http://www.terracycle.net/

In Practice

The Swiss textile company Rohner Textil AG produced the first 100 per cent biodegradable commercial fabric for the furniture provider Steelcase, informed by cradle-to-cradle principles and brought about through networking and collaboration with many partners. The revolutionary new fabric dramatically reduced manufacturing costs, due to savings in waste disposal, eliminating the need to filter toxic dyes and reducing paperwork. The water from the factory that manufactures the new fabric is as clean as, or cleaner than, the water in the town's drinking water supply. The firm turned a sustainability idea into an opportunity for both growth and differentiation. Adapted from Larson (2006).

The cradle-to-cradle methodology has been refined and simplified, as an infrastructure has developed around it.[15] Numerous eco-industrial parks now exemplify the principles (Machiba, 2010).

In Practice

Herman Miller, a US office furniture supplier, used cradle-to-cradle ideas to design its office chair, the Mirra. Implementing the cradle-to-cradle model had a big impact on processes within the company, affecting design, manufacturing and supply chain management. Adapted from Lee and Bony (2008).

[15] See http://www.mcdonough.com/cradle_to_cradle.htm

2. Develop new networks into the wider social, economic, legislative systems and, particularly, into supply chains; develop long-term collaborative approaches with external partners

A wider systems perspective reflects industrial ecology, with business activities and outputs embedded in networks, community, collaborations and partnerships (Del Río, Carrillo-Hermosilla & Könnölä, 2010). Industrial ecology calls for a radical shift from firms existing in isolation and in competition to integrated collaborations, with the potential to bring game-changing systemic innovation.

Many studies stress the importance of developing extensive networks into the wider social, economic and legislative systems and emphasize the critical role sustainable supply chain management (SSCM).

SSCM moves the sustainability agenda beyond the boundaries of the firm. At its simplest level, SSCM addresses sourcing alternative materials or promoting sustainably managed resources such as timber and fish stocks. The broader systems view, exhibited by Organizational Transformational firms, considers environmental and social factors in the total value chain — from the original sourcing of raw materials, through the various companies involved in extracting and processing, manufacturing, distributing, consumption and disposal. To achieve effective SSCM, to make the whole supply chain sustainable, long-term collaboration is necessary with external partners. SSCM beyond Operational Optimization redefines relationships and promotes the idea of value networks rather than value

chains (Carrillo-Hermosilla et al., 2010). Some of the most significant sustainable supply systems for natural resources, such as the Forest Stewardship Council and the Marine Stewardship Council, developed as a result of partnerships of industry groups, social and environmental NGOs and the public (Gulbrandsen, 2005; Taylor, 2005).

In Practice

At InterfaceFLOR more than two-thirds of the overall environmental impact of a carpet tile is related to raw materials. Virgin nylon yarn alone makes up about half of the carpet's greenhouse gas emissions throughout its life cycle, so reducing the amount used is fundamental to the strategy of creating a more sustainable product. Adapted from Arratia (2010).

Firms wanting to achieve the greatest sustainability impact may choose to specifically but not exclusively target upstream green supply chain initiatives, where the greatest damage occurs in the extractive and primary processing industries (Huber, 2008).
The literature that focuses on supply chains subordinates social considerations. Given some firms' poor histories of attending to employees' and contractors' working conditions, it is curious that little research describes innovative strategies to address these challenges. Such studies may exist in another domain of research, such as human resources or social policy. Alternatively, perhaps these do not bring positive publicity in the same way that environmental innovations do and so firms have been less willing to be studied. We note, therefore, this gap in the research.
As noted earlier, Operational Optimization can inhibit more radical or discontinuous innovation due to a tendency to focus on incremental improvements. However, eco-efficient practices may be a stepping stone to more radical process innovations. Evidence of this tendency may be found in the wider systemic thinking evident in some firms' application of environmental management systems and life cycle analysis (Bos-Brouwers, 2010a).

3. Start from a vision of the future and work backward, rather than moving forward from the present; set audacious goals even when the route may be unclear

Some SOI techniques seek to overcome the constraints on innovation resulting from operating within existing technological and process-based patterns. In one alternative, known as "back casting" (Mulder, 2007; Partidario & Vergragt, 2002; Vergragt & Van Der Wel, 1998), Organizational Transformation innovators start with a vision of the future as their starting point for innovation. They then work backward to determine the actions necessary to achieve the vision. Back casting thus inspires innovation to reach for a future desired state rather than projecting a technologically optimized present. Forecasting, by contrast, relies on building on existing operating standards. Forecasting results in incremental innovations while back casting has systems-changing potential.

For example, Nigel Stansfield, InterfaceFLOR's Senior Vice President of Product and Innovation for Europe Middle East, Africa, India, commented on his company's strategy:

In Practice

InterfaceFLOR is gradually climbing higher up Mount Sustainability by continually looking for incremental changes to our products and processes. But we also look for the miracle — the solution that will create the radical change we need to achieve Mission Zero. We do this by viewing our products and processes from the top of the mountain looking down. Rather than just focusing on how we make what we already have more sustainable, we ask "what would we start with if we are trying to achieve true sustainability?" Source: Arratia (2010: 2).

PRODUCT INNOVATION

Product innovation can be nurtured through platforms, new knowledge sources and market opportunities.

1. Adopt a servitization strategy: supplement or replace products with services
2. Search for product innovation ideas in new areas: e.g. use biomimicry and engage with bottom-of-the-pyramid customers
3. Be attentive to disruptive and systems-changing innovation happening elsewhere
4. Learn lessons from local firms and from new innovation platforms such as frugal innovation

1. Adopt a servitization strategy: supplement or replace products with services

In Operational Optimization, the product life cycle constrains opportunities for innovation. Some firms have addressed this limitation by replacing products with services (known as servitization or product-service strategies). By focusing on functionality, product developers ask whether a tangible product is actually needed or whether it can be replaced with a service. They transition from checklist-based, green thinking to broader sustainability thinking. Servitization is a conceptual challenge in terms of product/service design, sometimes requiring that consumers be re-educated, particularly in developed economies, where consumers have become accustomed to ownership. Firms that have developed technological and R&D capabilities to deliver products face a challenge: the need to overcome the barrier their competency creates to doing things differently.

Underlying the concept of product servitization is the idea that human needs are fulfilled by services, not products (Vergragt & Van Der Wel, 1998). Customer value is based on functionality; customers buy the service, not the product. Environmental and social benefits accrue from a product service system (PSS), including fewer products being manufactured, which leads to associated reductions in resource destruction and accumulation of waste. A PSS also makes services available and affordable to customers for whom owning the product is beyond their reach or for those communities consciously deciding on a community-sharing model of consumption.

Product service systems illustrate what Clark et al. (2009) refer to as the essence of sustainable innovation, which does not necessarily lead to new technologies, but to rethinking how to meet everyone's needs and to

[16] But it is not clear how successful the initiative has been

sustain growth without costly social and environmental impacts. The PSS approach successfully addresses sustainability issues in both developed and developing economies.

In Practice

Interface transformed its business from selling carpets to offering a service package. It leased floor coverings and retained the responsibility for maintenance, such as replacing worn sections, thus avoiding the need to replace an entire carpet when a small section has worn through. This approach could potentially save Interface and its clients money, while reducing resource use.[16] Adapted from Carrillo-Hermosilla et al. (2010) and Joshi et al. (2008).

Tukker (2004) discusses eight archetypical PSS business models in terms of their value added for the business and the extent to which the PSS generates fewer material flows and emissions than the competing product-oriented models. (See Appendix 5 for a diagram of the business models and their relations.) The complexity of PSSs varies, though typically they co-ordinate a firm's long-term vision with a cluster of products, services, stakeholder groups, supporting networks and infrastructures (Luiten, Knot & Van Der Horst, 2001; Tukker, 2004).

Tietze et al. (2011) argue that firms must master three complementary capabilities to support PSS development: a product development capability, service development capability and, most critically, a network infrastructure development capability.

In Practice

Grameen Telecom's Village Phone Project provided telephone access to villagers for whom private phone ownership was not possible due to lack of infrastructure for land lines and prohibitively expensive cellular telephones. However, mobile telephones and a PSS model provided access for all villagers. Grameen Bank members took loans to lease or purchase mobile telephone sets and thus had the opportunity to start an additional business of providing mobile phone services in their village. Adapted from Singhal et al. (2008).

2. Search for product innovation ideas in new areas: e.g. use biomimicry and engage with bottom-of-the-pyramid customers

Innovators can also draw inspiration for product innovation from nature. The term biomimicry (Benyus, 1997) literally means "to imitate life." As a design science, biomimicry recognizes that current life forms are the result of 3.8 billion years of research and development and that natural organisms have survived by adapting to the planet's diverse conditions. By learning from materials, behaviours and processes observed in the natural environment, innovators can extract design principles to help solve human sustainability issues (Chang, 2010). Examples of biomimicry-inspired innovation include the following:

In Practice

Self-healing plastics inspired by the body's ability to heal wounds; the design of energy-efficient buildings drawn from termites' capability to keep their mounds at a constant temperature despite the fluctuation of outside temperatures; solar cells that mimic the photosynthesizing processes of plants; the hooking mechanisms on seeds that led to the invention of Velcro. Source: Chang (2010).

There is a potentially non-sustainable dimension to biomimicry (Chang, 2010). For example, the natural world includes predators and parasites, and organizations could adopt predatory and parasitic behaviours.

In Practice

University of Leeds researchers are studying the jet-based defence mechanism of the bombardier beetle to determine whether the insect can assist them in designing a re-ignition system for a gas-turbine aircraft engine in mid-flight. The beetle is capable of spraying potential predators with a high-pressure stream of boiling liquid. Source: Rice and Martin (2007).

The key message of biomimicry for business models is the systems view: nature does not degrade the systems it relies on to survive. Society's organizations, similarly, should not emit more carbon than plants can absorb, capture more fish than can reproduce or dump more materials than the local ecosystem can metabolize (Chang, 2010).

These objectives are difficult for businesses to achieve in isolation, and thus call for universal attention, the redesign of institutions and infrastructures, and a reconceptualization of the purpose of business.

3. Be attentive to disruptive and systems-changing innovation happening elsewhere

Firms can be constrained by existing infrastructural, institutional and regulatory frameworks. Developing economies are often unhindered by these legacy systems and thus are freer to redesign how products and services are delivered. Firms can be attentive to developing countries' systems-changing innovations that have the potential to change the basis of competition in domestic markets.

In Practice

In December 2009, Tata Chemicals Ltd. (TCL) introduced the "Tata Swach" (Hindi for "clean"), the world's cheapest household water purification system. Tata Group Chairman Ratan Tata stressed that the quest was not to create the cheapest product but to reach the largest number of people. The Swach, which was developed by TCL's Innovation Centre and built around natural, locally sourced materials and cutting-edge nanotechnology, does not use any harmful chemicals such as chlorine. Tata Swach became the world's most inexpensive water purifier, enabling a 50 per cent savings compared with its nearest competitor. The water purifier is a disruptive "good enough" product that reportedly complies with the U.S. Environmental Protection Agency standards. Adapted from Tiwari and Herstatt (2012).

This strategy is particularly true where the target consumer is the bottom-of-the-pyramid consumer who accepts a good enough, or a satisficing, model. Products in this model are characterized by a limited and simple functionality, sufficiency (being good enough), high reliability, ease of use and durability for intensive use (Zeschky, Widenmayer & Gassmann, 2011).

In Practice

Founded in 1976, Aravind Eye Care is the world's largest provider of cataract surgery. It provides end-to-end eye-care services and each year screens more than 2.7 million people and performs 285,000 surgeries. Avavind has adopted the assembly-line principle in its operation theatres: operating tables are set up side by side, and surgeons operate on adjacent tables, while patients are lined-up even as the first operation is being completed. The hospital pricing mechanism is based on an equitable "pay-as-you-can-afford" system, and approximately two-thirds of its patients pay nothing. Aravind remains profitable through fees collected from the one-third of patients who pay plus revenues from eye-related services and such products as intra-ocular lenses. The key to the hospital's success is its focus on one disease and one major process and its patient throughput. Adapted from Avital et al. (2007), Joshi (2010) and Prahalad (2010).

4. Learn lessons from local firms and from new innovation platforms such as frugal innovation

Innovators, particularly but not exclusively those operating in developing economies, learn lessons from local firms, frugal innovators and reverse innovators. Reverse innovators focus on bottom-up co-invention with partners to develop products for local markets through a low-cost local supply chain (Ray & Ray, 2010). The products may involve novel technologies (Govindarajan, 2012; Immelt, Govindarajan & Trimble, 2009; Van Der Kroft, 2010).

Frugal innovation re-assesses the cost/performance profile of product development to create good-enough products that meet consumers' basic needs. Frugal innovators develop relationships across the value chain and the wider stakeholder community in an effort to minimize the use of material and financial resources, overcome resource constraints, devise new methods of distribution and achieve scalability (Tiwari & Herstatt, 2012). This strategy involves reducing the costs of R&D by drawing on existing core technologies and modular designs, eliminating unnecessary functionalities, leveraging local talent, deploying labour-intensive and capital-sensitive processes throughout the value chain, and developing relationships with local partners to ensure a low-cost local supply chain (Ray & Ray, 2010).

Frugal innovation has much in common with jugaad innovation, a term recently coined by Radjou et al. (2012) from the Hindi term for "overcoming harsh constraints by improvising an effective solution using limited resources." Radjou et al. (2012) assert that visionary leaders can help to reinvent their organizations around the principles of jugaad innovation, either in one fell swoop or by adopting it in parts of their organization.

Frugal, jugaad and reverse innovation are becoming increasingly common and have systems-changing possibilities in both developing and developed economies. By focusing technology and product

development on the needs of the poor as well as building long term relationships with such partners as local communities, local companies and NGOs, firms can meet the dual goals of satisfying stakeholders' expectations for growth as well as satisfying social and environmental stakeholders (Hart and Christensen, 2002). See Appendix 6 for further illustrations of frugal and reverse innovations.

Such disruptive business models at the base of the pyramid offer important lessons to firms in a developed economy:

- Build diverse and multiple relationships — from local support through to government-level policy dialogue
- Form new alliances – e.g. for supply chain sustainability
- Consider local needs when developing products and services
- Leverage the strengths, capacity and capabilities of the local community, either by engaging them individually, by building on existing networks or by creating new networks
- Adapt products and processes and redesign business processes to fit the local context: re-invent cost structures, reduce costs, rethink functionality from product service systems, utilize renewable or human-made resources instead of non-renewable resources, draw inspiration from nature (biomimicry), rethink delivery and distribution methods
- Adopt a stakeholder rather than shareholder view of the firm: understand that the organization's success is inextricably linked to the success of its stakeholders

For Organizational Transformers operating in underserved markets, the required innovation strategy is not to fine-tune systems, optimize existing processes or ship end-of-line or discontinued products to emerging markets, but to place the TBL at the centre of the business model. Multinational corporations (MNCs) can learn both from the innovative business models emerging domestically in these countries and from their own ventures in these markets in which the principles of the sustainable business model, so much as they are currently understood, can be piloted in separate ("ring-fenced") initiatives, e.g. in departmental, product-level or SBU-level experimentation.

In Practice

Cisco, a global networking technology company, invested in Aavishkaar, a venture fund founded to promote development in rural and semi-urban India. Cisco aims to promote technology-enabled inclusive growth and seeks to use this investment as a way to both learn about the market and accordingly align technology innovation. Adapted from UN Global Compact & Rockefeller Foundation (2012).

Local firms can use innovative approaches when delivering products and services to the underserved. MNCs can learn lessons from these experiences (Prahalad & Hart, 2002) through "learning investments" (UN Global Compact & Rockefeller Foundation, 2012): strong anecdotal evidence supports pro-poor innovation — both for those living in poverty and by those living in poverty — as a stimulant for creating new business models. Many cases of social innovation in new or niche markets start outside the mainstream,

where innovators understand customers (Lettice & Parekh, 2010), as with the Grameen Village Phone Project (Singhal et al., 2008).

In Practice

In China, mobile telephone services were principally targeted toward relatively affluent individuals living in urban areas. To the extent that they were served at all, bottom-of-the-pyramid (BOP) customers in rural areas were sold "out-of-date" phones. This business model was changed with the introduction of a new, domestically developed chip: simpler and cheaper than other chips, but with limited stability. Existing manufacturers would not use the chip because of the stability issue, but it provided a "good enough" cell phone for BOP users. A network of users, distributors, designers and manufacturers united around the opportunity that this chip offered in a "network-based value eco-system." Within this eco-system, small- and medium-sized enterprises (SMEs) and local entrepreneurs worked with BOP groups to design products that showed an understanding of local needs and local manufacturing capability. The cellular phone was technologically "deskilled," thereby allowing local entrepreneurs and SMEs to be involved and thus building local capability from the bottom up and providing access to mobile telephony. Adapted from Zhou et al. (2011).

SUMMARY

In Organizational Transformation, SOI takes on an increasingly societal and systemic character, which involves a change in the firm's underlying motivations. Innovation goes beyond mere compliance and the boundaries of the firm's manufacturing and production processes into the market, the supply chain and the wider social and institutional environment: areas where managers have less control and must take on a wider systems perspective. Firms are also experimenting with sustainability at a sub-organizational level.

Firms may appear to be inconsistent: sustainably oriented in one domain, while business-as-usual in the other. Indeed, concurrently holding two such positions has much in common with the notion of the ambidextrous organization.[17] Ambidexterity emphasizes the firm's ability to re-allocate, re-combine and reconfigure assets, resources and structures in face of environmental change.

There are also echoes of the skunk works made famous by Lockheed — in an effort to foster innovation, organizations split off from the main body to gain physical and cultural distance from established ways of doing things.

The best prospects for transition may then be areas where the firm is able to initiate a "shadow-track" activity alongside regular business activities (Loorbach et al., 2010). Incumbent firms may need to develop capabilities to manage the disruptive implications of

[17] The term ambidexterity was coined by Duncan (1976) to describe firms that perform exploratory and exploitative activities one after the other, not concurrently. The more contemporary view suggests that ambidexterity is the contemporaneous practice of both. Too much structure leads to rigidity, and too much exploration leads to chaos. Ambidexterity is characterized by the effective balance between the two.

such innovations. Much more difficult, however, is the transition to a Systems Builder orientation, which demands wholesale organizational change. We found no examples of such a transformation having been successfully achieved.

SOI in the context of systems building

Systems Building is an aspirational context. It is, arguably, a logical extension of the ambitions of more progressive firms and reflects the ideas of more prescriptive research. Systems Builders:

1. Derive new value propositions from entire socio-technical and ecosystem value network to make a positive impact with an inclusive business
2. Engage in institutional dialogues to "change the rules of the game"
3. Reframe the purpose of the firm: suffuse and infuse all dimensions of TBL into the organization
4. Initiate, mobilize, lead and inspire systems change
5. Apply equal weight to all aspects of the TBL in organizational thinking and decision-making

1. Derive new value propositions from entire socio-technical and ecosystem value network to make a positive impact with an inclusive business

Systems Building goes beyond the SOI of individual firms, to consider how the relationships between business practice, government policy and cultural behaviour co-evolve and can be leveraged for wider systemic change. This is about business acknowledging its responsibility to employees, citizens, communities and the natural environment.

2. Engage in institutional dialogues to "change the rules of the game"

Being a Systems Builder means leaving behind the dominant, traditional economic paradigm. This step beyond efficiency, notwithstanding organizational experimentations, continues to present an as yet insurmountable challenge: for incumbent firms, it requires transformational change, strong and visionary leadership, a shift in values and cultures, strategic repositioning and a readiness to sacrifice short-term self-interest for long-term community and environmental benefit. Transforming the system involves working collaboratively with government bodies and civil society groups to change the "rules of the game" in order to advance a broader sustainability agenda: for example, to influence capital markets and investors to attend to and integrate sustainability metrics.

3. Reframe the purpose of the firm: suffuse and infuse all dimensions of TBL into organization

The firm seeks to make a net positive impact through a clearly articulated ethical position that is reflected in its multiple stakeholder relationships targeted toward contributing to wider social and environmental change. This change marks a radical reframing of the purpose of the firm and a new definition of corporate purpose within society.[18] However, it also requires a fundamental

[18] BCorps, for example, express this as "Best for the World" as opposed to "Best in the World." See http://www.bcorporation.net/.

institutional redesign of not only the firm but also the social, economic and political institutional infrastructures in which firms are located. Achieving such changes is likely beyond the individual capacities of most firms.

4. Initiate, mobilize, lead and inspire systems changes

The ultimate objectives of sustainability may lie beyond the individual capacity of firms to achieve, but firms' role as Systems Builders becomes one of initiating, mobilizing, inspiring and leading this change: business is uniquely placed – more than government or civil society – to lead toward a sustainable world (Hart, 2010). Sustainable development cannot logically be an attribute of a single firm or entity but can only be properly applied at the global level (Lamming, Faruk & Cousins, 1999). Systems Builders are not wholly or solely responsible for addressing sustainability challenges, but firms leading in sustainability practice do not only focus internally but also look to lead and inspire change in the wider societal, economic, technical and environmental management systems.

5. Apply equal weight to all aspects of the TBL in organizational thinking and decision-making

The implications for innovation are profound, especially in terms of treating the TBL dimensions with equal importance and recognizing social aspects that are largely neglected by Operational Optimizers. Research on such innovation uses different rhetoric around the purpose of business. McDonough and Braungart (2002: 1), for example, write about the need for "nurturing solutions very different to the often outrageous initiatives that harm the environment." Chang (2010) suggests moving away from metaphors of war and competition, which can inappropriately inform leaders' decision-making, and instead using metaphors that describe businesses as part of a co-operative community based on relationships.

discussion

Firms are re-embedding themselves in society. Most firms haven't moved beyond the Operational Optimizer context. But firms are experimenting with greater innovation.

This review highlights limitations of the literature: little attention to social aspects of sustainability, and little attention to industries other than manufacturing and process.

A marked and radical shift in business firms' relations with society occurred around the middle of the 19th century, when "economic life became disembedded from society and viewed itself as a self-contained system consisting of consumers and their needs awaiting fulfilment by producers" (Polanyi, 1944, cited in Simanis & Hart, 2009: 79). At that time, the most polluted town in England was Bradford, where mill workers endured unimaginable conditions of employment, and life expectancy was only 20 years. On the back of technological innovation, Titus Salt wove alpaca wool with a silk or cotton warp to create a cloth of the finest quality, and, in so doing, amassed a fortune. He moved his mills out of Bradford and built a new industrial community, the eponymous Saltaire.[19] Salt built 850 houses for his workers, each served with fresh water from Saltaire's own reservoir. He also built shops, schools and Sunday schools, baths, washhouses, almshouses, a club and institute, a Wesleyan chapel, a magnificent Congregational church and a park (Ingham, 2006; Smith, 2003). In the context of Victorian England, Saltaire is an exemplar case of SOI or corporate social responsibility — though, of course, the term was not coined until considerably later. There are other similar examples, too, especially among the Quaker families, including the Cadbury family and Bournville (Lamming et al., 1999).

Of course, socially responsible thinking has moved on since the 1850s, and, although Saltaire may have been an exemplar of local social responsibility, the contemporary picture is made more complex by additional considerations, such as the ecological impact of industrial processes, the use of non-renewable sources of energy and interactions with suppliers. But, perhaps the sustainability orientation is not a wholly new phenomenon and organizations need not be disembedded from society, but perhaps instead need to acquire the capability to re-embed themselves.

At the end of the 20th century and the beginning of the 21st century, firms were reacquainting themselves with the principles of SOI and taking ideas further, heralding a new era of innovation activity and opportunity. Whether driven by regulatory obligations, competitive opportunity or the desire to "do the right thing," firms engage in a range of innovation-related practices under the banner of sustainability.

We note two categories of practice that we have labelled Operational Optimizers and Organizational Transformation. We also note an aspirational third category, Systems Builders, but find no empirical instances of firms operating in this context. In this last category, because the emphasis is on Systems Building, "the firm" may not even be the relevant unit of analysis.

Of the studies reviewed, the great majority focus on the innovation activities of Operational Optimizers. There are several explanations for this. First, at the start of our period of study (1992), many firms innovated as a reaction to regulatory requirements. Second, technological and management innovations offered opportunities to integrate sustainability thinking into existing operations and to deliver efficiency savings and

[19] Now a UNESCO world heritage site, see www.saltairevillage.info

competitive advantages. Third, firms found it easier to integrate sustainability thinking into existing systems rather than reinvent the way they worked.

However, from a sustainability perspective (i.e. climate change, resource depletion, emissions, biodiversity loss, social equity and fairness), it became apparent that Optimization could not and would not deliver the necessary changes. As a result, some pioneering firms began exploring the possibility of moving beyond Optimization and toward Systems Building.

Many firms now embrace SOI principles. By 2011, more than 250,000 firms in 155 countries had achieved ISO 14001 certification, which focuses on environmental dimensions, but many more firms have not yet achieved it (ISO, 2011). For firms yet to embark on the sustainability journey, what is an appropriate point of entry?

BEGINNING THE SUSTAINABILITY JOURNEY

Some firms, such as Desso, have attempted to leap the chasm between Operational Optimization and Organizational Transformation through activities described in the review, including the setting of audacious goals; investment in new technologies; working with their suppliers; collaborating with new partners, including policy-making bodies; and integrating cradle-to-cradle principles throughout their operations. Others engage with SOI on a more piecemeal basis, in an ambidextrous fashion, in which sustainability emerges at different rates within the firm.

Our review does not clarify whether the activities we have identified exist in a hierarchy or whether different configurations better suit different contexts. There is no one-size-fits-all model. Clearly, firms have a choice of options depending on their circumstances. In firms where sustainability is a contested philosophy, “low-hanging fruit” may offer an appropriate point of entry — a series of quick wins to demonstrate the business case. Process and primary industries, for example, may have outstanding issues, such as emissions, resource degradation or social exploitation, which, if addressed, would enhance those organizations’ legitimacy.

It is not an all-or-nothing scenario. Incumbent firms are experimenting with new configurations and new modes of operating. The transition from Operational Optimization to Organizational Transformation need not be attempted in a single leap. This review will help firms navigate the steps they might take in making this journey.

limitations of the review

The methodology and a descriptive analysis, presented in Appendices 1 and 2, illustrate an evolving research field, but one that is young, widely distributed and of variable quality. Studies are largely prescriptive and tend to be dominated by case histories and so a cumulative tradition has yet to develop. Longitudinal studies are rare, and causal relationships have not been explored, though a number of studies note correlations between sustainable innovation and organizational performance.

Nevertheless, this field of study is increasingly finding a voice in mainstream academic journals, which is evidence of the growing importance of the topic, a wider interest and increasing recognition. These studies enable us to identify actions that firms are taking in support of SOI. Especially in the context of Organizational Transformation, many firms' activities remain exploratory and experimental.

The imbalance in the literature weights our findings heavily in the direction of manufacturing and process industries. Typically, SOI activity in these sectors has focused on technological developments in products and processes. Much SOI in automotive industries, for example, was initially targeted at reducing CO2 emissions and subsequently at improving efficiencies; in the electronics industry, SOI has been directed toward reducing power consumption through product modification and (re-)design; and, in the iron and steel industry, concern about the availability of raw materials is reflected in efforts toward process optimization (OECD, 2010).

The imbalance in the literature suggests that the social dimension of sustainability does not receive as much attention from firms as environmental considerations. Further, we found no studies identifying or reporting on a fully sustainable business. Numerous commentators observed that, despite some firms' best efforts, there exist no empirical examples of a truly sustainable business, and we are unlikely to encounter any without a wider, systems-level institutional change.

previous reviews

Earlier literature reviews show how the field of Sustainability-Oriented Innovation (SOI) has changed over time. This review extends previous work by capturing the dynamic nature of SOI and its changing focus.

Numerous previous reviews relating to SOI were identified in the course of this research, and their findings are summarized in Table 3. They demonstrate a variety of perspectives on SOI or, more accurately, eco-innovation as the social dimension appears very late in studies. Early reviews focus on the implications of eco-innovation, adopting a principally technological/R&D/product development perspective: Winn and Roome (1993) report that the literature describes R&D for environmental considerations as a set of tools and techniques, Johansson (2000) explores the factors associated with the integration of eco-design into product development and Baumann et al. (2002) focus on product development.

The later reviews reveal how the literature has burgeoned to reflect a better understanding of the multidimensionality of the phenomenon, the range of factors that drive it (Pereira & Vence, 2012) and the complexity of its management (Klewitz & Hansen, 2011; OECD, 2009). Although the OECD's (2009) study notes that eco-innovations in manufacturing still tend to focus on technological advances, a few advanced players are starting to adopt new business models and alternative modes of provision (see the section on Product Service Systems above). In developing a conceptual framework of SOI in SMEs, Klewitz and Hansen (2011) draw attention to SOI's multi-dimensionality: firms have a range of strategy options; innovation takes a variety of forms, including degree of novelty and area of focus (process, product business model, etc.); and, depending on their orientation, firms' SOI may be more or less strongly influenced by regulators or market conditions.

In spite of this expanded domain, it is not until Schiederig et al.'s (2012) review and conceptual clarification that the social dimension of sustainability properly emerges. In the studies identified in the current review, we also note the under-representation of the social dimension. This neglect is being addressed mostly by studies that consider social aspects in less developed and developing economies, most notably in studies related to bottom-of-the-pyramid innovation (e.g. Anderson & Billou, 2007; Anderson & Markides, 2007; Prahalad, 2010; Prahalad & Hart, 2002; Prasad & Ganvir, 2005). However, the social aspect remains largely neglected in studies of SOI in developed economies.

Since the 1990s, the literature has moved from being largely normative and prescriptive to being more descriptive of what firms are actually doing: only 10 per cent of the studies included in Baumann et al.'s (2002) review were empirically based or tested. However, Baumann et al.'s (2002) observation that the literature is fragmented and disjointed holds true today.

A limitation of these previous reviews is their adoption of a relatively narrow view of innovation activity. Klewitz and Hansen's (2011) thematic analysis focuses on SOI practices with regard to product and process innovations, but it and the other reviews identified in Table 4 do not account for the greater complexity of SOI (Dangelico & Pujari, 2010; De Marchi, 2012; Wagner, 2009) or its socio-technical dimension.

The current study extends these previous reviews in several ways. First, it offers a sense of a dynamic phenomenon. That is, SOI is not an event but something that happens over time. The end-point has yet to be fully defined but it is clear that firms are increasingly being pressured to move forward from Operational Optimization to a reframed purpose that is firmly embedded in communities. As a result, we draw attention to the socio-technical nature of innovation: a narrow internal focus gives way to a broader systemic view and sustainability principles become deeply ingrained into organizational DNA.

Table 3

PREVIOUS RELATED REVIEWS

STUDY	PURPOSE	FINDINGS
Winn and Roome (1993)	To consider recent literature on R&D management responses to environmental challenges and the implications of environmental concerns for R&D management practice	• R&D management and the environment are described as being at a relatively early stage of development. • R&D management and the environment are regarded in the literature as a set of tools and techniques rather than a strategic management issue. • Emergent literature is beginning to consider organizational and technological change.
Johansson (2000)	To review the literature to identify factors associated with the integration of eco-design into product development	Factors for successful integration of eco-design cluster into the following areas: • Management: support, goal-setting, strategy. • Customer relationships: customer-centred focus and training. • Supplier relationships: close supplier relationships. • Development process: environmental factors articulated clearly and considered early in the process and integrated into regular R&D processes, use of support tools, use in cross-functional teams. • Competence: education and training of personnel, including environmental specialists. • Motivation: champions, engagement, inclusivity and environmental mindsets.
Baumann et al. (2002)	To review the conceptual and empirical literature on green product development, 1970 to 1999	• Literature on environmental product development (EPD) begins growing around 1990. • Less than 10 per cent of the literature was empirically based or tested. • Literature is fragmented and tends toward the normative or prescriptive. • Green product development is often treated in the literature as a new subject. The platform of departure is not current product development theory or practice. • Some articles question the importance of green products and the need for change of existing theories or current business practices. • Most references reflect a Western perspective. Little attention is paid to developing countries and their specific environmental problems. • Ecological and environmental considerations are becoming widely adopted in the product design process, moving from a previous perception of being anti-industry.

STUDY	PURPOSE	FINDINGS
Del Brío and Junquera (2003)	To review the literature on environmental innovation management in small and medium-sized enterprises (SMEs) — takes a strategy-oriented perspective	SMEs are different from multinational enterprises (MNEs) and require specific support from public administrations to promote sustainability-oriented innovation (SOI). The determining factors of SMEs' environmental strategy alternatives include financial resources, organizational structure, management style, human resources, environmental management status, manufacturing activity, technological approach, innovative capacity and external co-operation.
OECD (2009)	To review relevant concepts and practices relating to sustainable manufacturing and eco-innovation for policy and practitioner audience	• Practices for sustainable manufacturing have evolved from end-of-pipe solutions to a focus on product life cycles, integrated environmental strategies and integrated management systems. • Sustainable manufacturing calls for multi-level eco-innovations: integrated initiatives such as closed-loop production can potentially yield higher environmental improvements but require appropriately combining a wide range of innovation targets and mechanisms. • Eco-innovations in manufacturing tend to focus primarily on technological advances, though some advanced players have adopted new business models or alternative modes of provision.
Klewitz and Hansen (2011)	To systematically review 82 peer-reviewed publications regarding sustainability-oriented innovation in SMEs, 1987 to 2010	A conceptual framework of SOI in SMEs can be developed, consisting of the following: • Strategic orientation: a focus on being reactive, compliant, proactive, innovative. • Degree of innovativeness: reactors are incremental, innovators are more radical. • Predominant practices: from incremental process innovations to product and business model innovations. • Mechanisms of influence: reactors are driven by regulation, innovators are more influenced by and influence collaborations and partnerships. • Involvement of external actors: engagement of governments, regulators, value chain partners and knowledge institutions. • Predominant driver: external regulation gives way to a market-driven orientation.
Schiederig et al. (2012)	To clarify the concept of "green innovation" and to provide an overview of the existing body of literature in the field of green innovations, 1990 to 2010	When referring to green innovation, a range of synonymous terms are used interchangeably, including sustainable innovation, environmental innovation and ecological innovation. These terms have only minor conceptual differences. In both conceptualization and operationalization, the ecological dimension is privileged over the social dimension. In the fields of business, administration, finance and economics, the focus of study is on economic topics at the medium and large scales of innovation science (i.e. at the industry level and national policy level) not at smaller scales, such as managerial topics (i.e. at the intra-firm level). Journal of Cleaner Production is identified as the most prolific publisher in these fields.
Pereira and Vence (2012)	To explore the determinants of eco-innovation at the firm level, 2006 to 2011	The following determinants of eco-innovation are identified: • Sector: the greatest activity is observed in the most polluting sectors. • Financial: eco-innovation is not incompatible with business logic, can affect efficiency savings and competitiveness. • Market expectations: consumers are an increasingly important driver. • Technological capabilities: such as R&D. • Use of tools: adoption of environmental management systems and other tools such as life-cycle assessment and eco-labelling can positively influence eco-innovation.

additional materials

The appendices detail:

- The process for conducting this review
- The shape of the literature on Sustainability-Oriented Innovation
- Definitions of related terms
- Earlier stage models of Sustainability-Oriented Innovation
- The model of Product Service Systems
- Examples of frugal, reverse and social innovations

acknowledgements

The authors would like to acknowledge the financial support of Network for Business Sustainability, without which this report would not have been possible.
We would also like to acknowledge the invaluable contributions and commentaries we received from the inception of this project through to its conclusion from the NBS Guidance Committee, Pam Laughland, Maya Fischhoff and Stu Hart.

We must also pass our thanks on to those business people, policy-makers and academics who have shown an interest in this project and have contributed conversations, unpublished studies and other insights that have helped to clarify the subject.

appendix 1: methodology

The systematic review remains a novelty in management and organization studies (MOS), despite considerable methodological development drawing on experiences in other disciplines, particularly medicine. However, MOS offers a particular context of its own, and, with an orientation both to be rigorous and to address the practical implications of the work, we were guided by the approach first outlined by Tranfield et al. (2003).

The text of the original call asked for a review on "What best practices drive innovation and intrapreneurship for sustainable business?" The terms sustainable business, innovation, intrapreneurship and best practice are charged with a variety of meanings and have been applied throughout the MOS literature. To solely use these keywords to locate sources would result in returns that would be both unfeasibly large and predominantly irrelevant. Consequently, an early task was to ensure that we sufficiently focused the research question that would guide our review and search strategy to enable us to deliver a meaningful set of answers to address the core issues of the study.

Following discussions with the project's Guidance Committee, we arrived at the following research question: "What characterizes the innovation processes and innovation management practice of sustainability leaders?" However, after exploring several academic databases for studies that combined the keywords innovation, sustainability and leadership, we realized that the leadership criterion would likely result in both a very small number of returns and a review constrained in its practical usefulness for firms beginning the process of becoming sustainable. That is, by definition, only a small number of organizations are operating at the leading edge of sustainable business practice. These firms are radically innovating across multiple domains and in some cases are wholly redefining the purpose and place of business within society. Although lessons from these firms are valuable, we felt that they might limit the practical utility of this review for firms earlier on the sustainability journey. Consequently, we chose not to focus exclusively on the practices of leading firms but, instead, to portray how business can use innovation to progress toward sustainability leadership. In other words, "How does innovation make sustainability happen?" Consequently, our review focused on the following question: **What are the innovation activities firms engage in to become sustainable?**

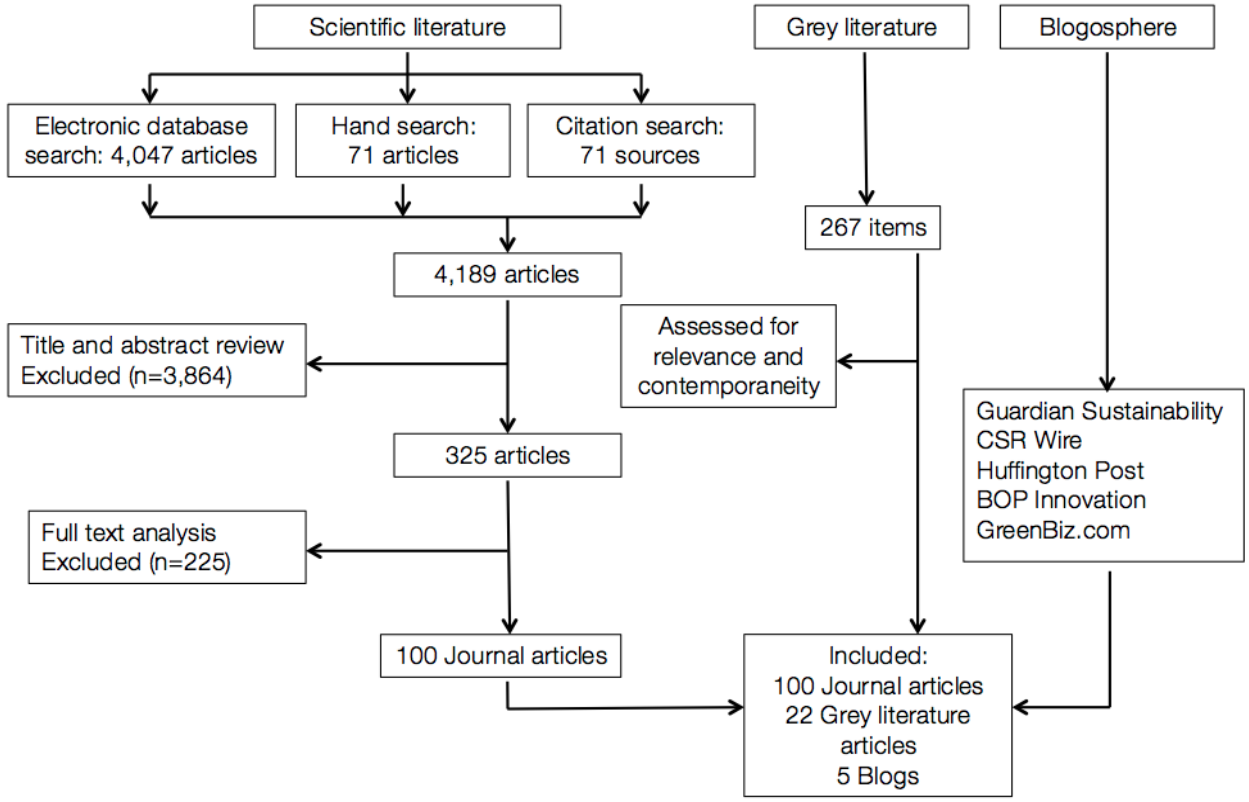
SEARCH STRATEGY

Our search strategy consisted of looking for relevant studies in both the scientific literature and among non-academic (grey) literature sources. The scientific literature is represented by academic studies published in peer-reviewed journals. The grey literature consists of studies, case histories, government, corporate and institutional reports, practitioner press, magazine articles, theses and even blogs that have not been subject to the same critical review and revision that characterize the peer-review process. Both the scientific and grey literature offer particular types of insight for this review.

The process of our search is illustrated in figure 3.

Figure 3

MAPPING THE LITERATURE SEARCH



SEARCHING THE SCIENTIFIC LITERATURE

Inclusion/exclusion criteria

Our criteria for determining which studies to include from the scientific literature are detailed in Table 4.

Table 4

INCLUSION AND EXCLUSION CRITERIA

CRITERION	INCLUSION	EXCLUSION
Study type	Empirical studies only, qualitative or quantitative. Does the study report empirical findings?	Theoretical or conceptual studies
Study length*	≥7pages/ @3,000 words	<7pages/ @3,000 words
Language	English	Any other language
Sector	Private sector	Any other sector
Time period**	1992 to 2012	Any study published before 1992
Relevance***	• Sustainability-oriented innovation management • Addresses sustainable innovation targets • Addresses sustainable innovation processes • Level of analysis – firm-level practices and processes • Innovation consistent with sustainability principles: at least one of the three pillars of sustainability (environmental, social or economic), but not solely the economic pillar	• Not directly relevant to the research questions – e.g. sustainability only in the sense of continuance • Fails to address the substantive research question • Level of analysis – not firm-level practices and processes (e.g. community initiatives and activities) • Not the management and organization studies literature

*To exclude reports produced for public relations purposes, we wanted to ensure that activities reported in this review had been uncovered through a process of empirical research. We adopted the criterion of Bertels et al. (2010), who determined that studies with fewer than seven pages were unlikely to discuss empirical findings in sufficient detail to provide such assurance.

**We chose to search for documents published within the period of 1992 to 2012. The start date of 1992 was chosen as this was the year of the United Nations Conference on Environment and Development, the so-called Rio Summit.

***Not all innovations are sustainable. Studies must demonstrate consistency with the World Commision on Environment and Development (1987: para 49) definition that sustainability is “seeking to meet the needs and aspirations of the present, without compromising the ability to meet those of the future” and involves intentionality. Sustainable innovation targets products, services, processes and factors within the organizational domain with the intention of improving organizational, social and environmental performance.

Developing search strings

In the management literature, the terms sustainability and innovation have been interpreted broadly, used in diverse ways and applied in a variety of contexts. We thus required a tightly defined research strategy when using these terms as a basis for a literature search to return primary studies addressing our specific research question.

An initial scoping of the literature helped to identify keywords to use when constructing search strings. With the support of the Guidance Committee, we developed and refined this list over a number of iterations, resulting in the list presented in Table 5.

Table 5

KEYWORDS

THEME	SYNONYMS AND ALTERNATIVES
Sustainability	environmental* OR green* OR corporate social responsibility OR csr OR corporate sustainability OR eco-innovation OR green technology OR renewable* OR social responsibility OR environmental social responsibility OR social environmental management OR sustainable develop* OR triple bottom line OR eco-efficien* OR eco-effectiv* OR sustainable development indicator* OR sdi OR sustainability-oriented innovation OR soi OR biomimicry OR beyond-greening OR frugal innovation OR reverse innovation OR trickle up innovation OR cradle to cradle OR social innovation OR iso 14001 OR bottom of the pyramid OR bop
Innovation	innovat* OR innovation management OR innovation process* OR innovation activit* OR implement* OR adopt* OR diffus* OR R&D OR invent* OR new product development OR npd OR radical innovation OR incremental innovation OR disruptive innovation OR discontinuous innovation OR continuous improvement

Search methods

We used the following methods to search the literature: search of electronic databases, citation searching and hand searching.

Electronic databases

Between March and June 2012, we searched a range of electronic databases using configurations of the keywords listed in Table 5. The returns for each database are detailed in Table 6.

Table 6

DATABASE PAPER SELECTION

DATABASE	NUMBER OF DATABASE RETURNS	NUMBER REMAINING AFTER ELIMINATION BASED ON REVIEW OF ABSTRACTS AND TITLES	ULTIMATELY SELECTED PAPERS
EBSCO Business Source Complete	2,097	187	67
IBSS	148	18	0
ISI Web of Knowledge	1,156	74	12
JSTOR	209	4	0
ZETOC	49	16	2
Energy Citations	6	1	0
BASE	382	25	2

Citation and hand searching

As we located the studies identified for inclusion, we scanned their reference sections for the citations of relevant articles. Similarly, we carried out forward citation searches to identify additional relevant papers that cited the studies identified for inclusion. This approach is intended to identify a cluster of papers that are related and therefore highly relevant. Citation searching is not suitable for identifying recently published papers because not enough time has passed for these papers to have been cited. Because of this gap, we also conducted a hand search of key journals.

The complete results for our different search approaches are detailed in Table 7.

SEARCHING THE GREY LITERATURE

Typically, reviewers are reluctant to include the grey literature in systematic reviews. Increasingly, though, the weight of opinion is changing, as inclusion of the grey literature can have the following effects:

- Counter-balance publication bias (i.e. publications that tend to promote positive findings) (Hopewell, McDonald, Clarke & Egger, 2007)
- Address the problems of time lag (Conn, Valentine, Cooper & Rantz, 2003)
- Provide more contemporary, relevant and contextually important findings; the assurance that all possibly relevant avenues were explored; and support for "the wisdom of practice," which may not find support or be reflected in the scientific evidence (Benzies, Premji, Harden & Serrett, 2006)

Table 7

RETURNS FROM DIFFERENT SEARCH STRATEGIES OF THE SCIENTIFIC LITERATURE

SOURCE	NUMBER OF RETURNS	NUMBER REMAINING AFTER ELIMINATION BASED ON REVIEW OF ABSTRACTS AND TITLES	ULTIMATELY SELECTED DOCUMENTS
Total electronic databases	4,047	308	83
Hand and citation search	142	17	17
Total scientific literature	4,189	325	100

At the outset of this project, the research team and the Guidance Committee shared the belief that the grey literature would make an important contribution to the substantive review. This belief was rooted in our sense that although the concept of sustainable business has a relatively long history, until recently, it has received little research attention. Thus, we reasoned that recent activities in the field, including the more cutting-edge practices, were unlikely to have entered the academic literature. This view is supported in the literature (e.g. Winn & Roome, 1993).

This view was reinforced as we searched the literature through the established academic databases. As we developed our framework, consisting of three contexts of sustainability-oriented innovation, we noted the scarcity of studies that could be allocated to the third context — Systems Building. We also noted a lag between the date that a scientific study occurred and the date of its publication. Of the studies that included the date of the commencement of the research (n=35), the average lag from study to publication was four years (s.d. 2.8 years). Thus, on average, a study published in 2012 reports on work that was undertaken in 2008. The practice of some aspects of innovation may be ahead of the academic research and, thus, may not be reported in scholarly journals. Further, as our descriptive statistics show, the SOI literature is widely distributed and relatively immature: as yet, it does not have a clearly defined specialist literature. Because of such conditions, we paid special attention to compensating search strategies, such as asking experts about more recent findings and examining the grey literature (McManus et al., 1998).

Electronic databases can be limited in their usefulness for searching the grey literature in MOS (Greenhalgh & Peacock, 2005). Although these databases can help to identify conference and working papers, they can overlook informative practitioner literature. So, in addition to electronic databases, our search strategy included the following:

- Requests to experts in the field, including:
  - Two *Academy of Management* listservs: (1) Technology and Innovation Management and (2) Managing for Sustainability
  - Email requests to 218 experts in sustainability
- Internet search of key practitioner websites including:
  - European Commission Eco-Innovation Projects
  - FTSE4Good
  - United Nations Development Programme
  - European Forum for Sustainable Development and Responsible Business
  - United Nations Environmental Programme
  - United Nations Global Compact
  - World Environment Center
  - World Business Council for Sustainable Development
  - Environmental Protection Agency
  - Global Reporting Initiative
  - European Union Eco-Innovation Observatory
  - International Institute for Sustainable Development
  - The Centre for Sustainable Design
  - United Nations Environment Programme/ Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production

    - Consultancy services (Accenture, Arthur D. Little, Boston Consulting Group)
    - Academic learning case repositories (European Case Clearing House, Harvard University)
- Search of five sustainability blogs: Guardian Sustainability, CSR Wire, Huffington Post, BOP Innovation, GreenBiz.com

Strategies to search the grey literature are difficult to design and time-consuming to execute. There is not an established method for searching grey literature, being systematic is difficult, and the endeavor is very resource intensive. Benzies et al. (2006) reported that including the grey literature in their review required employing two research assistants for eight months to search and retrieve literature.

Regrettably, this project lacked the resources to adequately analyze the grey literature we discovered. Although we received a disappointing response to our calls to listservs and the expert panel, our searches on websites and sustainability blogs uncovered a stream of teaching- and consultancy-based case studies and histories: a rich collection of individual stories of SOI and prescriptions relating to innovative behaviour that seemingly were not making their way into the scientific literature — at least not in a timely fashion.

The uncovered sources were of mixed quality: many reported only single cases and failed to report on methodology, triangulation, validation and confirmability. However, these characteristics were also found in the scientific literature.

To retain a level of systematicity and to address the publication time lag identified above, we focused our selection criteria for the grey literature on topical relevance and contemporaneity, or recency of publication. We identified a short list of 267 items , subsequently reduced to 27 (five books/chapters, one case study, three conference papers, 11 reports/ practitioner press, one thesis and five sustainability blog posts).

Due to time and resource constraints, we were unable to include all the excellent case study material that is available, particularly through oikos[20], the World Resources Institute's Sustainable Enterprise Program (SEP) Bell project[21], the Harvard Kennedy School CSR Initiative[22] and several consulting firms. These materials are worthy of a content analytic study in their own right.

DATA EXTRACTION

Our search, assessment and retrieval process largely followed the process outlined in Barroso et al. (2003). A research assistant scanned all citations identified from the various databases and web searches. Approximately 10 per cent of these citations were also reviewed by two authors (SJ and HM) to validate selections. Disagreements were resolved by discussion. After scanning titles and abstracts, and then full texts of articles, 100 scientific studies were considered eligible.

A data extraction form was constructed for this review, and data were extracted onto a Microsoft Excel worksheet.

[20] See www.oikosinternational.org/
[21] See www.BELLinnovation.org
[22] See http://www.hks.harvard.edu/m-rcbg/CSRI

Data were coded according to bibliographic characteristics of the source, study design, quality criteria, innovation area of focus, innovation novelty and processes of innovation (coding of the grey literature focused only on innovation area of focus, innovation novelty and processes of innovation). Each of these themes is developed further in the section Descriptive Analysis.

DATA SYNTHESIS

To help organize the data, we developed a conceptual framework of contexts of Sustainability-Oriented Innovation (SOI). To build a picture of innovation in each context, where studies permitted, we allocated examples of innovation activities and targets to the appropriate context. In some studies, though, it was unclear in which context the activity or target belonged, and some studies covered more than one context.

We screened the relevant papers and identified descriptions of innovation relating to two themes (area of focus and process). By considering these themes of innovation and the three contexts of SOI, we extracted data from the primary studies into what essentially became a two-by-three matrix. Data were initially extracted verbatim from studies along with annotations and memos and displayed in the matrix. This approach allowed a systematic process of aggregating and integrating innovation activities around these particular themes and contexts. This matrix formed the basis of the analysis described in this report.

appendix 2: descriptive analysis

BIBLIOGRAPHICS

Journals and rankings

We found the literature to be disjointed, widely distributed and skewed, as have others (e.g. Baumann et al., 2002; Klewitz & Hansen, 2011; Schiederig et al., 2012). On the basis of the included studies, we conclude that the academic study of SOI is represented across a diverse, distributed and immature body of literature: we have included 100 articles selected from 54 separate journals. Thirty-six journals provided one article each, and 18 journals each provided two or more articles. Figure 4 and Table 8 show the number of articles provided by different journals.

SOI has proved relatively slow in finding exposure in the mainstream journals, including the innovation journals. Two journals, Business Strategy and the Environment and Journal of Cleaner Production, accounted for 26 per cent of the included studies. The former is ranked as a number 2 publication, and the latter is not ranked

Figure 4

JOURNALS PROVIDING 2 OR MORE PAPERS (NUMBER OF PAPERS)

Table 8

JOURNALS PROVIDING ONLY A SINGLE PAPER

- British Journal of Management
- California Management Review
- Clean Technologies and Environmental Policy
- Construction Management and Economics
- Economic Geography
- Energy Policy
- Environmental Management and Health
- Global Business and Organizational Excellence
- Greener Management International
- IEEE Transactions on Engineering Management
- Industrial Management and Data Systems
- Innovation: Management, Policy and Practice
- Interfaces
- International Economics and Economic Policy
- International Journal of Automotive Technology and Management
- International Journal of Environment and Sustainable Development
- International Journal of Environmental Technology and Management
- International Journal of Innovation and Technology Management
- International Journal of Innovation Management
- International Journal of Management
- International Journal of Technology Management and Sustainable Development
- Issues in Social and Environmental Accounting
- Journal of Business Research
- Journal of Computer Information Systems
- Journal of High Technology Management Research
- Journal of Management Studies
- Journal of Manufacturing Technology Management
- Journal of Marketing Management
- Management of Environmental Quality: An International Journal
- Management Research Review
- Organization and Environment
- Service Business
- Sustainable Development
- Technological Forecasting and Social Change
- Technology and Society Magazine, IEEE
- Technovation

according to the Association of Business Schools rankings for 2010. Journals are ranked on a scale of 1 (lowest quality) to 4 (highest quality).

The next most prolific journals each provided three papers for this review, and their rankings are as follows:

- European Journal of Innovation Management, ranked 1
- International Journal of Innovation and Sustainable Development, not ranked
- Journal of Business Ethics, ranked 3
- Management Decision, ranked 1
- R&D Management, ranked 3
- Sustainability, not ranked

Six journals of the highest rank (4) provided a total of only eight articles for this review, five of which have been published since 2007:

- British Journal of Management (one article: 2002)
- California Management Review (one article: 2001)
- Economic Geography (one article: 2001)
- Journal of Management Studies (one article: 2012)
- Journal of Product Innovation Management (two articles: 2012)
- Research Policy (two articles: 2007, 2012)

Increasing research interest

As Figures 5 and 6 show, the field is attracting greater levels of research interest.

Figure 5

PUBLICATIONS PER YEAR, 1992 TO 2012

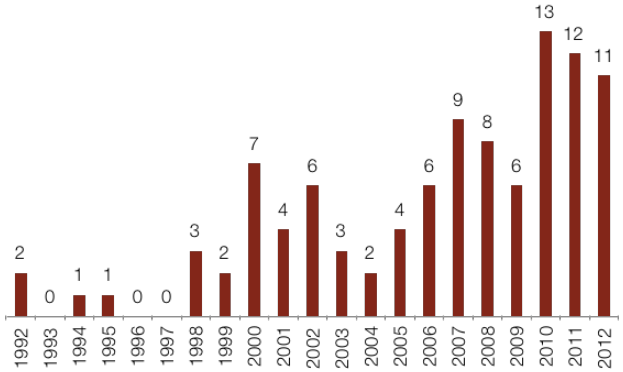
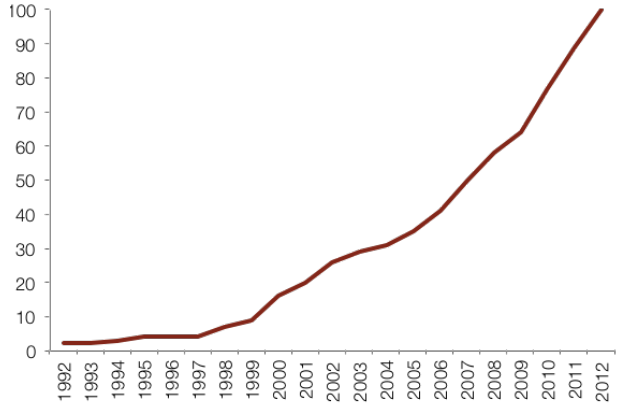


Figure 6

CUMULATIVE PUBLICATIONS, 1992 TO 2012



DESIGN OF STUDIES

Sectoral distribution

Figure 7 illustrates the sectoral focus of scientific papers included in the review. Of the 100 scientific papers, 33 represent mixed-sample studies. The mixed-industrial category consists of a range of industry types, whereas the mixed-various category includes studies that consider a diversity of sectors such as manufacturing, services and charities.

The service and consumer goods sectors are underrepresented, and manufacturing and process industries are overrepresented, which reflects a focus in the literature on environmental considerations. Until recently, the literature on SOI has focused on technical processes, with work largely done by scholars in science and engineering. As recently as 2010, Bos-Brouwers (2010b) showed that many sustainable innovations are incremental and focused on improving technological processes (i.e. eco-efficiency) and lowering production costs.

On the basis of this distribution, it is difficult to draw conclusions relating to SOI in different sectors.

Country distribution

Figure 8 illustrates the geographical distribution of the scientific studies. This distribution shows global interest in the topic, though the greater proportion of single-country studies focus on the developed economies. Just less than one-third of the studies reviewed adopted a multi-country focus, ranging from cross-country case studies (e.g. Clark et al., 2009) to surveys across Europe (e.g. Wagner, 2008).

Figure 7

DISTRIBUTION OF PAPERS BY SECTOR (NUMBER OF PAPERS)

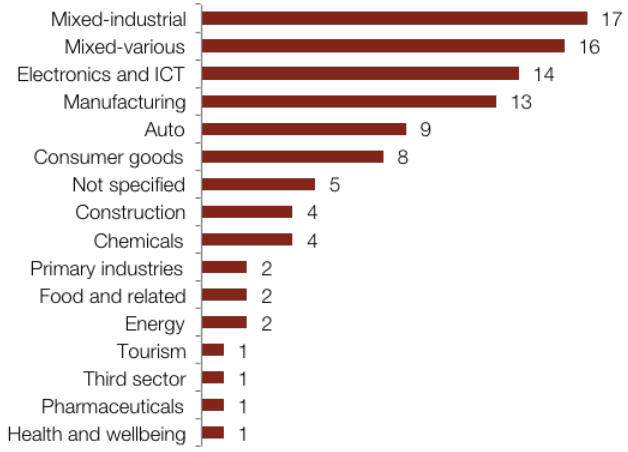
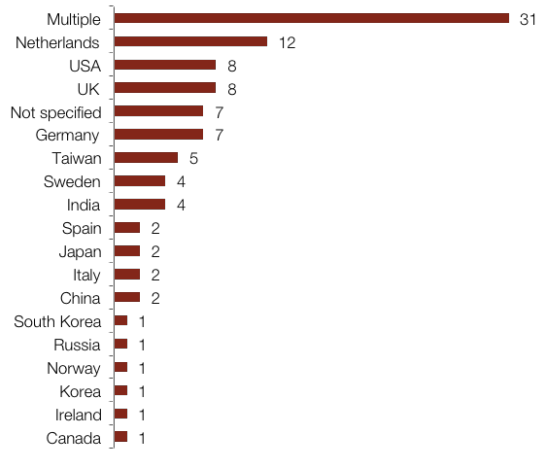


Figure 8

COUNTRY FOCUS OF SCIENTIFIC STUDIES (NUMBER OF PAPERS)



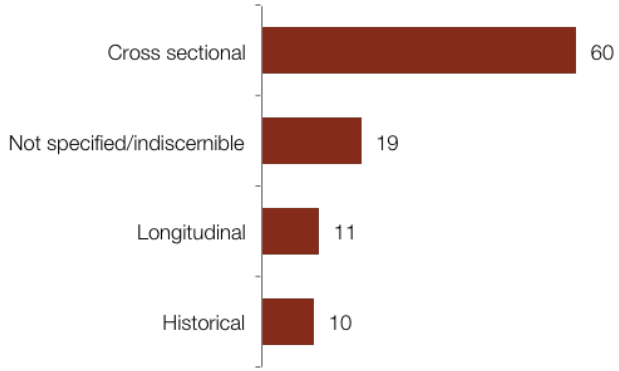
Study methodologies

Figure 9 shows that 60 per cent of included studies adopted a cross-sectional approach; the remaining 40 per cent of studies were longitudinal (11 per cent), historical (10 per cent) or did not have a discernible perspective (19 per cent).

As Figure 10 shows, the single preferred methodology was qualitative (46 studies, 46 per cent), and the next most preferred method, quantitative (24 studies, 24 per cent). A large proportion of studies (22 studies, 22 per cent) did not make explicit their methodology — though they mostly reported on single case histories.

Figure 9

STUDY TEMPORAL PERSPECTIVES (NUMBER OF PAPERS)

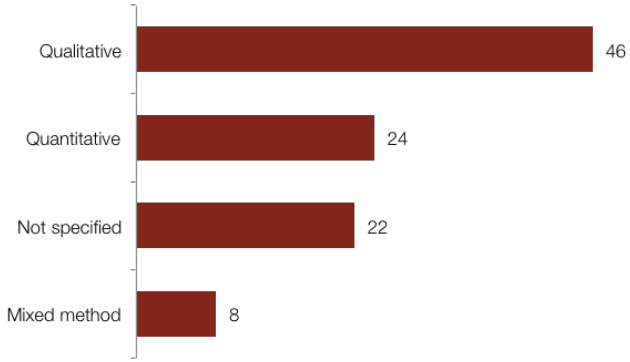


QUALITY APPRAISAL

The role of quality appraisal of studies in systematic reviews in MOS is contested. The role for quality appraisal in systematic review was originally conceived as a filtering mechanism to exclude possibly biased studies or other factors that might affect the "truth" of the conclusions. MOS consists of diverse types of evidence, characterized by different epistemological and ontological positions. As a result, the purpose that quality appraisal serves and its position in systematic review have been re-assessed. Quality appraisal has not been widely reported in many of the systematic reviews published in peer-reviewed MOS journals,

Figure 10

STUDY METHODOLOGIES (NUMBER OF PAPERS)



which speaks to the contestation around its use, the difficulty of execution and the confusion about the role of such appraisals in studies that draw on evidence not derived from randomized controlled trials.

For this review, we assessed the quality of studies not to filter out studies, but to describe the range of quality across included studies in order to reflect on the strength of evidence underpinning the findings. As we have already noted, most studies informing this review are qualitative. No standardized criteria exist for the appraisal of qualitative studies. Researchers whose systematic reviews have included qualitative and mixed-method studies have adopted a variety of approaches, from not applying quality criteria and thus keeping all relevant data, to seeking objectivity by applying checklists.

We assessed the quality of studies on three dimensions: generalizability, technical accomplishment and strength of evidence. Generalizability refers to the extent to which findings apply beyond the immediate context of the study. To this end, we used Daly et al.'s (2007) hierarchy of evidence for practice in qualitative research. This hierarchy emphasizes research's ability to provide evidence-for-practice or evidence-for-policy. It consists of four levels (see Table 9) and we put each of the studies in one of these.

Table 9

HIERARCHY OF EVIDENCE FOR PRACTICE IN QUALITATIVE RESEARCH
(Source: Daly et al., 2007)

STUDY TYPE	FEATURES	EVIDENCE IMPLICATIONS FOR PRACTICE
Generalizable studies	Sampling focused by theory and the literature, extended through analysis to capture diversity of experience. Analytic procedures comprehensive and clear. Located in the literature to assess relevance to other settings.	Clear indications for practice or policy. May offer support for current practice, or critique with indicated directions for change.
Conceptual studies	Theoretical concepts guide sample selection, based on analysis of literature. May be limited to one group about which little is known or a number of important subgroups. Conceptual analysis recognizes diversity in participants' views.	Weaker designs identify the need for further research on other groups, or urge caution in practice. Well-developed studies can provide good evidence if residual uncertainties are clearly identified.
Descriptive studies	Sample selected to illustrate practical rather than theoretical issues. Record a range of illustrative quotes including themes from the accounts of "many," "most," or "some" study participants.	Demonstrate that a phenomenon exists in a defined group. Identify practice issues for further consideration.
Single case study	Provides rich data on the views or experiences of one person. Can provide insights in unexplored contexts.	Alerts practitioners to the existence of an unusual phenomenon.

As Figure 11 shows, the included studies are predominantly single case or descriptive in nature. These two categories in Daly et al.'s (2007) hierarchy offer the lowest potential to generalize beyond the immediate context of the study.

Single case studies can provide important insights into novel or under-explored phenomena. Descriptive studies extend these results by providing more accounts from more participants but findings are analyzed with little regard to their applicability in other contexts.

The 10 conceptual and generalizable studies in the review are primarily quantitative and provide more generalizable support for the importance of the following activities in SOI:

- Stakeholder engagement
- Performance monitoring and engagement
- Innovation capabilities
- Sustainability culture and top management support
- Experimentation

Technical accomplishment reflects the reviewers' subjective opinion regarding how well a study has been executed, also known as its methodological rigour: whether the study has adequately applied the appropriate methods and whether qualitative research has applied the appropriate checks (e.g. triangulation and multiple coders).

Figure 11

SELECTED STUDIES' CAPABILITIES TO PROVIDE EVIDENCE FOR PRACTICE (NUMBER OF PAPERS)

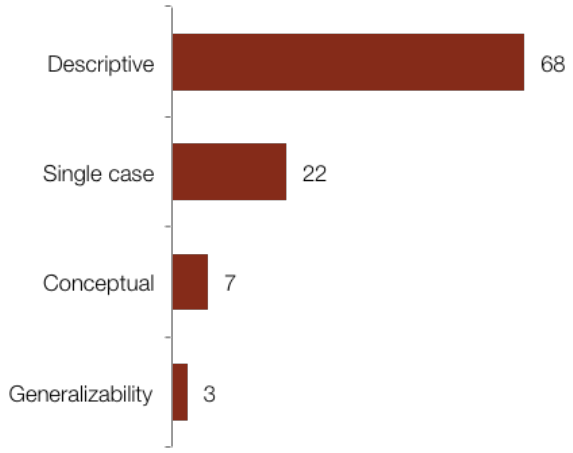
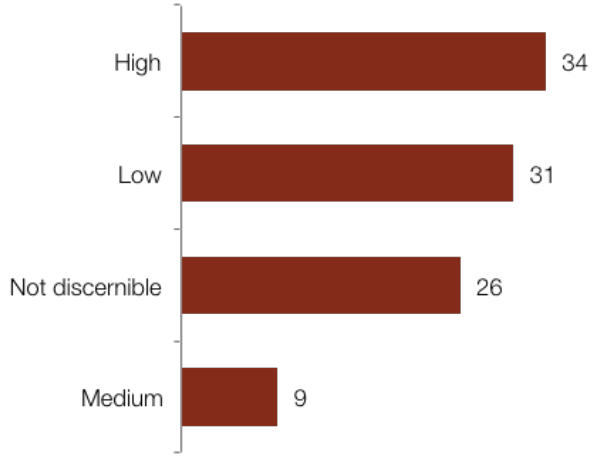


Figure 12

TECHNICAL ACCOMPLISHMENT



The studies in our sample are mixed in their technical accomplishment, with an approximately equal number of well- and poorly-executed studies. A little over a quarter of the studies did not report in sufficient detail to allow us to judge their level of technical accomplishment.

To assess the strength of evidence of included studies, we adopted Reay, Berta & Kohn's (2009) rubric, modified from a model for evaluating the quality of medical research (Table 10). Their hierarchy differentiates levels according to the strength of evidence generated.

The distribution of the studies included in this review according to Reay et al.'s (2009) classification of levels of evidence is presented in Figure 13 and shows our sample to consist exclusively of evidence of levels 3, 4 and 5. The strongest level of evidence was level 3 and the weakest, level 5: the most frequently referenced level was level 4.

Table 10

HIERARCHY OF STRENGTH OF EVIDENCE
(Source Reay et al., 2009)

Level 1 evidence (strongest) is generated through…
- RCTs [randomized controlled trials] or meta-analyses

Level 2 evidence emerges from…
- (a) A high-quality literature review that is replicable and comprehensive and provides a synthesis and actionable recommendations based on the synthesis or (b) a systematic literature review.

Level 3 evidence is garnered through…
- Comparative, multisite case studies or large-sample quantitative studies involving data collected from more than one site (organization).

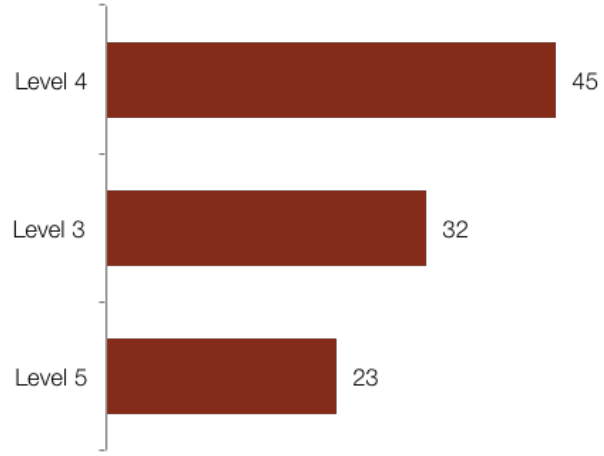
Level 4 evidence is gathered through…
- Small-sample, single-site qualitative or quantitative studies. These studies are theoretically motivated and are completed by trained (management) researchers who have (at most) an arm's-length relationship with the organization under study; the "voice" of these studies is objective.

Level 5 evidence is generated through…
- Descriptive studies and/or self-report stories. These studies generally include observations, admonitions, and recommendations relevant to managers. Early papers important to the then "new" area of evidence-based management offered emerging theory bolstered by Level 5 evidence.

Level 6 evidence (weakest) is based on…
- The opinion of respected authorities or expert committees without additional data. Some papers offer anecdotal evidence as a means of supporting such opinions.

Figure 13

STRENGTH OF EVIDENCE



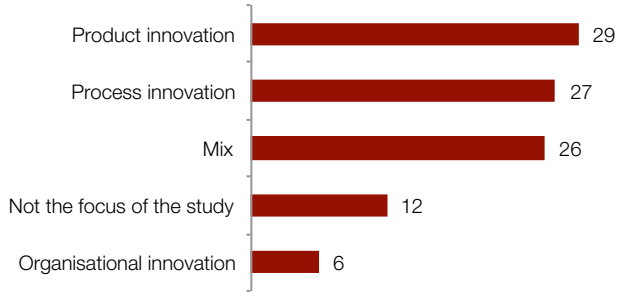
INNOVATION AREA OF FOCUS

Area of focus refers to innovation type. Product innovations change what the organization offers to the outside world; process innovations change the way the organization produces and delivers those offerings (Bessant et al., 2005). Innovations may also occur in some other part of the organizational domain (e.g. management or business model).

Studies of product and process innovation dominate our selection, and a much smaller number of studies consider organizational innovation.

Figure 14

STUDIES ADDRESSING TYPE OF INNOVATION

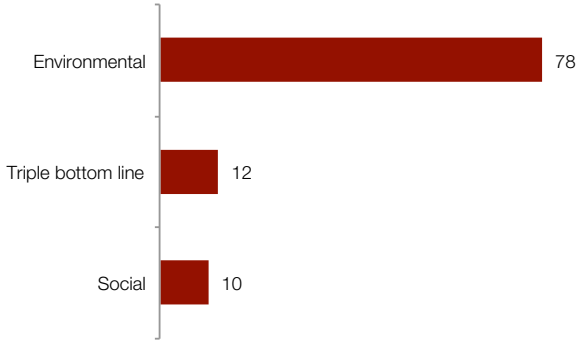


Dimension of sustainability

It is often not possible to be definitive about studies' focus of attention between social innovation, environmental innovation and a more inclusive triple-bottom-line approach. Numerous studies refer in general terms to sustainability and do not distinguish between innovations with a social focus and those with an environmental focus. Other studies discuss, for example, innovation at the bottom of the pyramid, where a social dimension is implied but the environmental dimension is not clear. However, from our selected studies, clearly the great proportion of attention has focused on environmental considerations. The social dimension of sustainability-oriented Innovation is massively under-represented. Figure 15 represents our best characterization.

Figure 15

STUDIES ADDRESSING DIMENSIONS OF SUSTAINABILITY



THE ELEMENTS OF INNOVATION

A traditional model of innovation distinguishes between core elements or steps and broader enabling processes in the organization (Tidd and Bessant, 2009). The core elements are:

- Search: What are the drivers and how can we find opportunities for SOI?
- Select: What are we going to do and why?
- Implement: How are we going to make it happen?
- Capture: How are we going to receive the benefits from it?

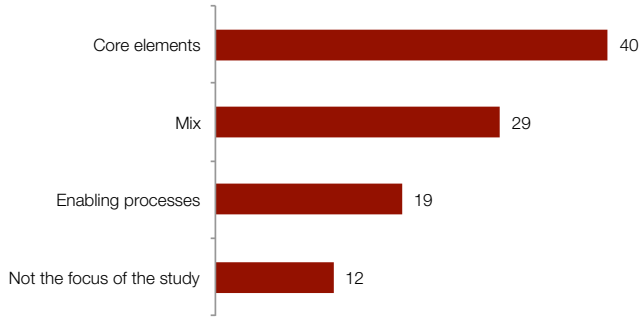
Which are nested within a set of enabling processes:

- Strategy: Is the strategy clear, is it supported and communicated?
- Culture: is the culture conducive to SOI?

Studies of SOI predominantly focus on the core elements together rather than a single element (Figure 16). We can interpret this lack of more nuanced investigations of particular elements as an indication of the immaturity of the field.

Figure 16

STUDIES ADDRESSING THE ELEMENTS OF INNOVATION



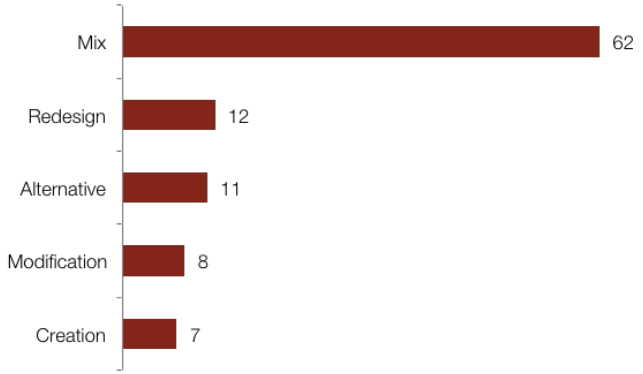
INNOVATION NOVELTY

To capture the novelty of the innovations included in selected studies, we utilize Machiba's (2010) classification developed expressly for the context of sustainable innovation. Machiba describes four degrees of novelty, reflected by the innovation moving from small, progressive product and process adjustments (modification) through more significant changes (re-design and alternatives) to the design and introduction of something entirely new (creation).

Because of the numbers of mixed studies, innovation novelty has not proven to be a useful analytic dimension in this review (Figure 17). Most studies report on innovations that exhibit mixed degrees of novelty, principally modifications and alternatives. Of the seven creation innovations, six are reported in papers published since 2010, the seventh having been published in 2000. Nine of the 12 redesign innovation studies have been published since 2004.

Figure 17

NOVELTY OF INNOVATION IN SELECTED STUDIES



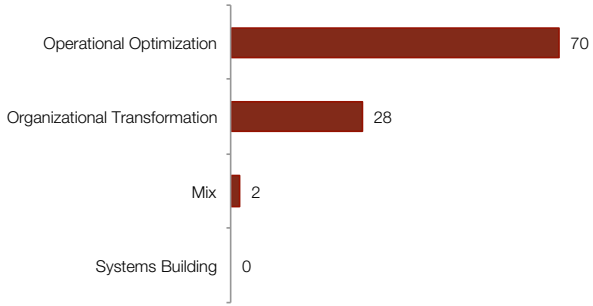
CONTEXTS OF SOI

Figure 18 illustrates the number of papers from our sample that address each of the three different contexts of SOI: Operational Optimization, Organizational Transformation and Systems Building.

Studies predominantly address Operational Optimization, and none were found that provided empirical instances of Systems Building. The latter finding either results from inadequacies in our search or serves to confirm the popularly held view that a truly sustainable company does not yet exist and is unlikely to exist until wider systems change occurs (Lamming et al., 1999). Nevertheless, the 28 Organizational Transformation studies — with one exception, all published since 2000 — indicate a trajectory toward Systems Building and provide evidence of firms' activities in pursuit of that objective.

Figure 18

NUMBER OF STUDIES ADDRESSING THE THREE CONTEXTS OF SOI



appendix 3: definitions of SOI

This review identified multiple definitions relating to SOI. The most salient are described below.

ECO-INNNOVATION
New products and processes that provide customer and business value and significantly decrease environmental impacts (Fussler & James, 1996). New products and processes that provide customer value, while using fewer resources and resulting in reduced environmental impacts (Johansson & Magnusson, 1998). New or modified processes, techniques, practices, systems and products aimed at preventing or reducing environmental damage (Rennings, 2000). Innovation that improves environmental performance (Arnold & Hockerts, 2011). Overarching concept that provides direction and vision for pursuing the overall societal changes needed to achieve sustainable development. Eco-innovation reflects an explicit emphasis on a reduction of environmental impact, whether such an effect is intended or not….It is not limited to innovation in products, processes, marketing methods and organizational methods, but also includes innovation in social and institutional structures (Machiba, 2010). New or modified processes, techniques, practices, systems and products to avoid or reduce environmental harms. Eco-innovations may be developed with or without the explicit aim of reducing environmental harm (Halila & Rundquist, 2011). Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resource use (including energy use) compared to relevant alternatives (Buttol et al., 2012).
ECOLOGICAL INNOVATION
The development and implementation of new products (environmental technologies), new production processes, new resources, new markets and new systems (e.g. transportation of goods), and all of them integrate economy and ecology, i.e. introduce ecological aspects in economic strategies (Blättel-Mink, 1998).

ENVIRONMENTAL INNNOVATION

Actions taken by individuals or teams that improve the environmental performance of companies. Pollution prevention initiatives, replacement of toxic or hazardous substances, dematerialization of products and replacing products with services are types of “eco-innovations” (Ramus, 2001).

The compliance efforts and efficiency improvements made to existing products and operations. Sustainability is defined as the innovative and potentially transformative corporate activities that generate new products and processes that challenge existing practice (Larson, 2000).

Any kind of innovations — technical, economic, legal, institutional, organizational and behavioural — that relieve strain on environmentally sensitive resources and sinks (Huber, 2008).

ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT

Development without growth in throughput of matter or energy beyond regenerative and absorptive capacities (Mirata & Emtairah, 2005).

FRUGAL INNOVATION

Seeks to minimize the use of material and financial resources in the complete value chain (development, manufacturing, distribution, consumption and disposal) with the objective of reducing the cost of ownership while fulfilling or even exceeding certain pre-defined criteria of acceptable quality standards (Tiwari & Herstatt, 2012).

GREEN INNOVATION

The improvement of products or processes for energy-saving, pollution-prevention, waste recycling, green product designs and corporate environmental management in the field of environmental management. Green innovation can be divided into green product innovation and green process innovation (Chang, 2011).

GREEN PRODUCT INNOVATION

A multi-faceted process aimed at minimizing environmental impacts while striving to protect and enhance the natural environment by conserving energy and resources (Lee & Kim, 2011).

INCLUSIVE INNOVATION

The development and implementation of new ideas that aspire to create opportunities to enhance social and economic wellbeing for disenfranchised members of society (George et al., 2012).

JUGAAD INNOVATION

A colloquial Hindi word that roughly translates as “an innovative fix; an improvised solution born from ingenuity and cleverness.” Jugaad is, quite simply, a unique way of thinking and acting in response to challenges; it is the gutsy art of spotting opportunities in the most adverse circumstances and resourcefully improvising solutions using simple means. Jugaad is about doing more with less (Radjou et al., 2012).

SOCIAL INNOVATION

Innovative activities and services that are motivated by the goal of meeting a social need and are predominantly developed and diffused through organizations whose primary purposes are social (Mulgan et al., 2007).

SUSTAINABILITY-RELATED AND SUSTAINABILITY-ORIENTED INNOVATION

Several possible interpretations: first, innovation explicitly directed at a sustainability goal — for example, generating electricity with lower emissions than current power stations produce. Second, innovation processes, which do not have sustainability issues as their primary target (e.g. the innovation process for a fast-moving consumer goods company producing new consumer products), but which try to adhere to sustainability targets during their development, production and use. Finally, innovation processes which are sustainable within the company. This usage is not linked to environmental or social goals: it is merely a statement that the company has an innovation renewal process that keeps its innovation engine running profitably (Blowfield, Visser & Livesay, 2007).

The renewal or improvement of products, services, technological or organizational processes to deliver not only an improved economic performance but also an enhanced environmental and social performance, both in the short and long terms (Bos-Brouwers, 2010a).

Realized ideas that improve environmental and/or social performance compared with the current situation (Arnold & Hockerts, 2011).

A tool both to address sustainability issues and to tap into new customer segments and markets (Hansen, Grosse-Dunker & Reichwald, 2009).

An improvement (and/or introduction) of a product, technology, service, process, management technique or business model, which, in comparison to a prior version and based on a rigorous and traceable (comparative) analysis, has a positive net effect on the overall capital stock (economic, environmental and social) (Klewitz & Hansen, 2011).

SUSTAINABLE BUSINESS

A business approach that strengthens both the business (i.e. generates profits, builds resilience, etc.) and society (i.e. generates positive externalities for the environment, communities, employees, etc.) (Network for Business Sustainability).

SUSTAINABLE DEVELOPMENT

To meet the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

The integration of environmental thinking into every aspect of social, political and economic activity (Elkington, 1994).

A process of achieving human development in an inclusive, connected, equitable, prudent and secure manner. Inclusiveness implies human development over time and space. Connectivity entails an embrace of ecological, social and economic interdependence. Equity suggests intergenerational, intra-generation and inter-species fairness. Prudence connotes duties of care and prevention: technologically, scientifically and politically. Security demands safety from chronic threats and protection from harmful disruption (Gladwin, Kennelly & Krause, 1995).

Seeks to meet the needs and aspirations of present higher forms of sentient life without compromising the ability to meet those of the future (Birkin et al., 2009).

appendix 4: models of sustainability-oriented innovation

After Kolk and Mauser (2002)

STUDY	MODEL	
Hunt and Auster (1990)*	• Beginner • Firefighter • Concerned citizen	• Pragmatist • Pro-activist
Roome (1992)*	• Non-compliance • Compliance • Compliance-plus	• Commercial and environmental excellence • Leading edge
Elkington (1994)*	• Ignorance • Awakening • Denial • Guilt reduction/displacement behaviour/tokenism	• Conversion • Integration
Shrivastava and Hart (1995)*	• Band aid • More serious	• Deep change
(Hart, 1997)	• Pollution prevention • Product stewardship	• Clean technology
Winn and Angell (2000)*	• Deliberate reactive greening • Unrealized greening	• Emergent active greening • Deliberate proactive greening
Low et al. (2001)	• Incremental improvements • Redesign of existing product concepts	• Alternative fulfilment of function • Designs completely fitting in the sustainable society
Keijzers (2002)	• Sanitize • Control	• Integrate
Dunphy et al. (2003)[23]	• Rejection • Non-responsiveness • Compliance	• Efficiency • Strategic proactivity • The sustaining corporation
Alakeson and Sherwin (2004)	• Single issue approach • Ad hoc approach	• Sustainability tools • Strategic integration
Tukker and Tischner (2006)	• System optimization • System re-design	• System innovation
Blake (2006)	• Protector • Builder	• Innovator

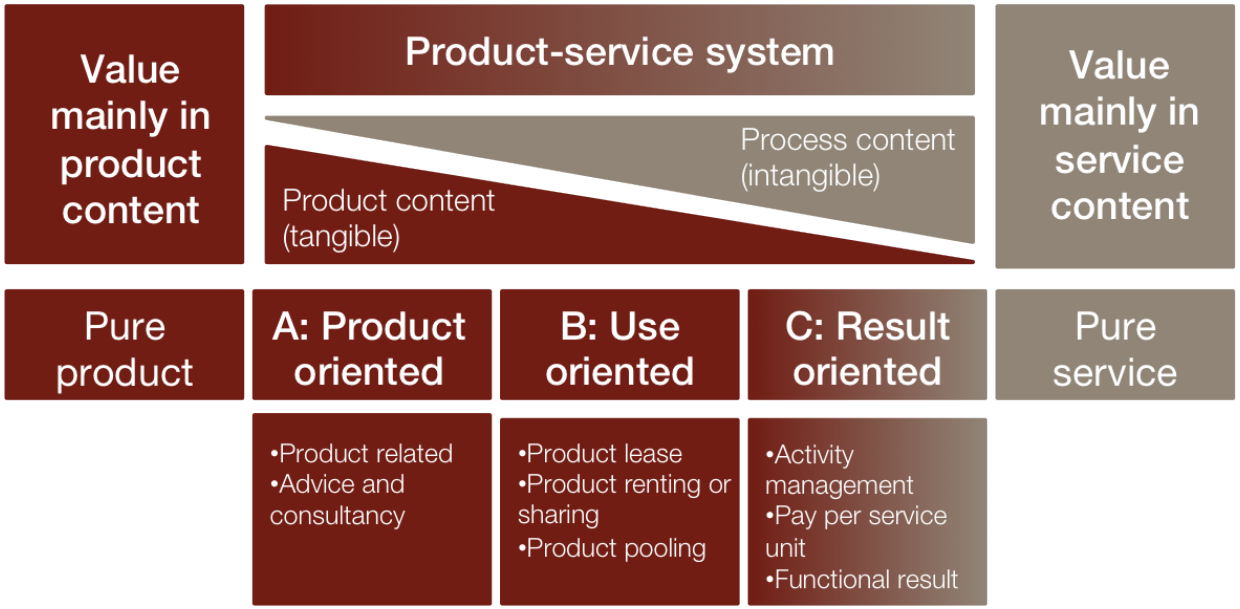
[23] As reported in Holton, Glass, & Price, 2010.

STUDY	MODEL	
Alexander Ballard Ltd. (2008)	• Core-business focused • Stakeholder responsive • Efficient management	• Breakthrough projects • Strategic resilience • Champion organization
Nidumolu et al. (2009)	• Viewing compliance as opportunity • Making value chains sustainable • Designing sustainable products and services	• Developing new business models • Creating next practice platforms
Morton and Grayson (2009)	• Deniers (it's not our fault) • Compliers (we'll only do what we have to) • Case-makers (it's the business)	• Innovators (it gives us a competitive advantage) • Trail-blazers (we need to make sure everybody does it)
Machiba (2010)	• Technological change	• Socio-technological change
Mani et al. (2010)	• Initial • Managed • Defined	• Quantitatively managed • Optimizing
Carrillo-Hermosilla et al. (2010)	• Component addition • Sub-system change	• System change
Baya and Gruman (2011)	• Compliance • Obligations	• Efficiency • Leadership
Seebode et al. (2012)	• Exploit • Bounded exploration	• Reframing • Co-evolution
Elkington (2012)	• Eureka • Experiment • Enterprise	• Ecosystem • Economy

Note: *Included in Kolk and Mauser's original review

appendix 5: the main and sub-categories of product service systems

Source: Tukker, 2004



appendix 6: frugal, reverse and social innovations

Frugal, reverse, and social innovations are important areas of exploration for companies. This table details recent examples.

INNOVATION	INNOVATOR	DESCRIPTION	SOURCE
Tata Nano	Tata Motors Ltd.	The world's cheapest car	Ray and Ray (2011)
Tata Ace	Tata Motors Ltd.	A small commercial vehicle costing 50 per cent less than any other four-wheeled commercial vehicle in India	Tiwari and Herstatt (2012)
Tata Swach	Tata Chemicals Ltd.	The world's cheapest household water purification system	Tiwari and Herstatt (2012)
Solar-powered Automated Teller Machine	Vortex Engineering (India)	Addresses local conditions, namely unreliable power supply and end users' higher illiteracy levels	Tiwari and Herstatt (2012)
ChotuKool refrigerator	Godrej & Boyce	Small size, high-end insulation, battery-operated capability and portability are design responses to the local context	Tiwari and Herstatt (2012); Bhatti and Ventresca (2012)
Weighing scale	Mettler Toledo	Limited functionality, sufficient accuracy, conventional materials, high reliability	Zeschky et al. (2011)
Portable ultrasound machine	GE	Simple functions, standard laptop for data processing and imaging unit, support of local language, portable, easy to use	Zeschky et al. (2011); Immelt et al. (2009)
Computer mouse M215	Logitech	Simple functions, established technologies (e.g. USB dongle, wireless connection), basic packaging, ease of use	Zeschky et al. (2011)
Bedside patient monitoring system	Philips	Simple functions, robust design, high reliability, ease of use	Zeschky et al. (2011)
Computed tomography (CT) scanner	Siemens	Simple functions, designed for intensive use and fast workflow, high reliability, ease of use	Zeschky et al. (2011)
Micro-finance	Grameen	Microloans	Bhatti and Ventresca (2012)
Intraocular lens	Aravind Eye Hospital	AuroraLab's $5 intraocular lens	Bhatti and Ventresca (2012)
Suzuki Maruti	Suzuki	Low-priced car for developed markets	Kang et al. (2009)
$800 cardiac surgery	Narayana Hrudayalaya Hospital Bangalore	Application of mass-production techniques to heart surgery	Bhatti and Ventresca (2012)
Zhongxing X-ray machine	Zhongxing Medical	At $20K, approximately 1/20th price of Western X-ray machines through designing out extraneous functionality	Sehgal et al. (2010)
Aakash Tablet	DataWind	$35 tablet for India's school children	Bhatti and Ventresca (2012)

references

Alakeson, V. & Sherwin, C. (2004). Innovation for sustainable development. London, UK: Forum for the Future.

Alexander Ballard (2008). Adaptive capacity benchmarking: a handbook and toolkit. http://www.espace-project.org. Accessed April 2012.

Alston, K. & Roberts, J.P. (1999). Partners in new product development: SC Johnson and the alliance for environmental innovation. Corporate Environmental Strategy, 6 (2), 110-128.

Anderson, J. & Billou, N. (2007). Serving the world's poor: innovation at the base of the economic pyramid. Journal of Business Strategy, 28 (2), 14-21.

Anderson, J. & Markides, C. (2007). Strategic innovation at the base of the pyramid. MIT Sloan Management Review, 49 (1), 83-88.

Anderson, N.R. & West, M.A. (1998). Measuring climate for work group innovation: development and validation of the team climate inventory. Journal of Organizational Behavior 19 (3), 235-258.

Arnold, M.G. & Hockerts, K. (2011). The greening Dutchman: Philips' process of green flagging to drive sustainable innovations. Business Strategy and the Environment, 20 (6), 394-407.

Arratia, R. (2010). Sustainable innovation: think big, be open to new ideas and embrace successful failure. www.interfaceraise.com. Accessed July 2012.

Aschehoug, S. H., Boks, C. & Støren, S. (2012). Environmental information from stakeholders supporting product development. Journal of Cleaner Production, 31, 1-13.

Avital, M., Lyytinen, K., King, J.L., Gordon, M.D., Granger-Happ, E., Mason, R.O. & Watson, R.T. (2007). Leveraging information technology to support agents of world benefit. Communications of AIS 2007, (19), 567-588.

Ayuso, S., Rodríguez, M.Á., García-Castro, R. & Ariño, M.Á. (2011). Does stakeholder engagement promote sustainable innovation orientation? Industrial Management and Data Systems, 111 (9), 1399-1417.

Barroso, J., Gollop, C.J., Sandelowski, M., Meynell, J., Pearce, P. F. & Collins, L. J. (2003). The challenges of searching for and retrieving qualitative studies. Western Journal of Nursing Research, 25 (2), 153–178.

Baumann, H., Boons, F. & Bragd, A. (2002). Mapping the green product development field: engineering, policy and business perspectives. Journal of Cleaner Production, 10 (5), 409-425.

Baya, V. & Gruman, G. (2011). Sustainability: moving from compliance to leadership. Technology Forecast: A Quarterly Journal, 4, 6-21.

Bendell, J. (2000). Terms for endearment: business, NGOs and sustainable development, Sheffield, UK: Greenleaf Publishing Ltd.

Benyus, J.M. (1997). Biomimicry: innovation inspired by nature, New York: HarperCollins.

Benzies, K.M., Premji, S., Hayden, K.A. & Serrett, K. (2006). State-of-the-evidence reviews: advantages and challenges of including grey literature. Worldviews on Evidence-Based Nursing, 3 (2), 55-61.

Bertels, S., Papania, L. & Papania, D. (2010). Embedding sustainability in organizational culture. A systematic review of the body of knowledge. London, Canada: Network for Business Sustainability.

Bertens, C. & Statema, H. (2011). Business models of eco-innovations: an explorative study into the value network of the business models of eco-innovations and some Dutch case studies. Project commissioned by Dutch Ministry of Infrastructure and Environment.

Bessant, J., Lamming, R., Noke, H. & Phillips, W. (2005). Managing innovation beyond the steady state. Technovation, 25, 1366–1376.

Bhatti, Y.A. & Ventresca, M. (2012). The emerging market for frugal innovation: fad, fashion, or fit? SSRN eLibrary http://ssrn.com/abstract=2005983.

Biondi, V., Iraldo, F. & Meredith, S. (2002). Achieving sustainability through environmental innovation: the role of SMEs. International Journal of Technology Management, 24 (5-6), 612-626.

Birkin, F., Polesie, T. & Lewis, L. (2009). A new business model for sustainable development: an exploratory study using the theory of constraints in Nordic organizations. Business Strategy and the Environment, 18, 277–290.

Blake, J. (2006). From protection to innovation: BT's journey in corporate social responsibility. Global Business and Organizational Excellence, 26 (1), 7-17.

Blättel-Mink, B. (1998). Innovation towards sustainable economy: the integration of economy and ecology in companies. Sustainable Development, 6 (2), 49-58.

Blowfield, M., Visser, W. & Livesey, F. (2007). Sustainability innovation: mapping the territory. Cambridge, UK: Cambridge Programme for Sustainability Leadership Paper Series, No. 2.

Blum-Kusterer, M. & Hussain, S.S. (2001). Innovation and corporate sustainability: an investigation into the process of change in the pharmaceutical industry. Business Strategy and the Environment, 10, 300–316.

Bos-Brouwers, H.E.J. (2010a). Corporate sustainability and innovation in SMEs: evidence of themes and activities in practice. Business Strategy and the Environment, 19, 417-435.

Bos-Brouwers, H.E.J. (2010b). Sustainable innovation processes within small and medium-sized enterprises. PhD thesis. VU University Amsterdam, Faculty of Economics, Business Administration and Econometrics.

Bossink, B.A.G. (2007). The interorganizational innovation processes of sustainable building: A Dutch case of joint building innovation in sustainability. Building and Environment, 42 (12), 4086-4092.

Bossink, B.A.G. (2002). A Dutch public-private strategy for innovation in sustainable construction. Construction Management and Economics, 20 (7), 633-642.

Bowen, F.E. (2002). Organizational slack and corporate greening: broadening the debate. British Journal of Management, 13 (4), 305-316.

Brezet, H. & Hemel, C.V. (1997). Ecodesign: a promising approach to sustainable production and consumption. Paris: United Nations Environmental Program (UNEP), Industry and Environment.

Buttol, P., Buonamici, R., Naldesi, L., Rinaldi, C., Zamagni, A. & Masoni, P. (2012). Integrating services and tools in an ICT platform to support eco-innovation in SMEs. Clean Technologies and Environmental Policy, 14 (2), 211-221.

Carrillo-Hermosilla, J., Del Río, P. & Könnölä, T. (2010). Diversity of eco-innovations: reflections from selected case studies. Journal of Cleaner Production, 18 (10/11), 1073-1083.

CERES. (2010). The 21st century corporation: the CERES roadmap for sustainability. Boston: Ceres.

Chang, C.-H. (2011). The influence of corporate environmental ethics on competitive advantage: the mediation role of green innovation. Journal of Business Ethics, 104 (3), 361-370.

Chang, Z.K. (2010). Biomimicry: tool for innovation at all levels of organization. Herndon, VA: Strategic Sustainability Consulting.

Chesborough, H.W. (2003). The era of open innovation. MIT Sloan Management Review, 44 (3), 35-41.

Clark, G., Kosoris, J., Hong, L.N. & Crul, M. (2009). Design for sustainability: current trends in sustainable product design and development. Sustainability, 1 (3), 409-424.

Cohen, W.M. & Levinthal, D.A. (1990). Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly, 35, 128–152.

Colby, C.C. (2011). The relationship between product design and business models in the context of sustainability. Masters thesis. University of Montreal.

Conn, V. S., Valentine, J. C., Cooper, H. M. & Rantz, M. J. (2003). Grey literature in meta-analyses. Nursing Research, 52 (4), 256-261.

Daly, J., Willis, K., Small, R., Green, J., Welch, N., Kealy, M. & Hughes, E. (2007). A hierarchy of evidence for assessing qualitative health research. Journal of Clinical Epidemiology, 60, 43-49.

Dangelico, R. & Pujari, D. (2010). Mainstreaming green product innovation: why and how companies integrate environmental sustainability. Journal of Business Ethics, 95 (3), 471-486.

De Marchi, V. (2012). Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. Research Policy, 41 (3), 614-623.

Del Brío, J.A. & Junquera, B. (2003). A review of the literature on environmental innovation management in SMEs: implications for public policies. Technovation, 23 (12), 939-948.

Del Río, P., Carrillo-Hermosilla, J. & Könnölä, T. (2010). Policy strategies to promote eco-innovation. Journal of Industrial Ecology, 14 (4), 541-557.

Dow Chemical Company. 2012. Sustainable chemistry. http://www.dow.com/sustainability/goals/chemistry.htm. Accessed June 2012.

Duncan, R.B. (1976). The ambidextrous organization: designing dual structures for innovation. In: Killman, R. H., Pondy, L. R. & Slevin, D. (eds.),The management of organization: 167–188. New York: North Holland.

Dunphy, D., Griffiths, A. & Benn, S. (2003). Organizational change for corporate sustainability. Abingdon, UK: Routledge.

Elkington, J. (1994). Towards the sustainable corporation: win–win–win business strategies for sustainable development. California Management Review, 36 (2), 90–100.

Elkington, J. (1997). Cannibals with forks. Oxford: Capstone.

Elkington, J. (1998). Partnerships from cannibals with forks: the triple bottom line of 21st-century business. Environmental Quality Management, 8 (1), 37-51.

Elkington, J. (2012). The zeronauts: breaking the sustainability barrier. Abingdon, UK: Routledge.

Esslinger, H. (2011). Sustainable design: beyond the innovation-driven business model. Journal of Product Innovation Management, 28 (3), 401-404.

EYGM (2012). Six growing trends in corporate sustainability: an Ernst and Young survey in cooperation with GreenBiz Group. Ernst and Young and GreenBiz Group.

Florida, R., Atlas, M. & Cline, M. (2001). What makes companies green? Organizational and geographic factors in the adoption of environmental practices. Economic Geography, 77 (3), 209-224.

Foster, C. & Green, K. (2002). Environmental innovation in industry: the importance of environmentally-driven users. International Journal of Environmental Technology and Management, 2 (4), 303-314.

Fussler, C. & James, P. (1996). Driving eco-innovation: a breakthrough discipline for innovation and sustainability. London: Pitman.

Geffen, C.A. & Rothenberg, S. (2000). Suppliers and environmental innovation: the automotive paint process. International Journal of Operations and Production Management, 20 (2), 166-186.

Geng, Y., Fu, J., Sarkis, J. & Xue, B. (2012). Towards a national circular economy indicator system in China: an evaluation and critical analysis. Journal of Cleaner Production, 23 (1), 216-224.

George, G., McGahan, A.M. & Prabhu, J. (2012). Innovation for inclusive growth: towards a theoretical framework and a research agenda. Journal of Management Studies, 49 (4), 661-683.

Gladwin, T.N., Kennelly, J.J. & Krause, T.S. (1995). Shifting paradigms for sustainable development: implications for management theory and research. Academy of Management Review, 20 (4), 874-907.

Govindarajan, V. (2012). A reverse-innovation playbook. Harvard Business Review, 90 (4), 120-124.

Greenhalgh, T. & Peacock, R. (2005). Effectiveness and efficiency of search methods in systematic reviews of complex evidence: audit of primary sources. British Medical Journal, 331 (7524), 1064-1065.

Gulbrandsen, L.H. (2005). Mark of sustainability? Challenges for fishery and forestry eco-labeling. Environment, 47 (5), 8-23.

Haanes, K., Arthur, D., Balagopal, B., Kong, M.T., Reeves, M., Velken, I., Hopkins, M.S. & Kruschwitz, N. (2011). Sustainability: the '"embracers" seize the advantage. MIT Sloan Management Review Research Report. MIT Sloan Management Review and The Boston Consulting Group.

Halila, F. & Rundquist, J. (2011). The development and market success of environmental innovations: a comparative study of environmental innovations and "other" innovations in Sweden. European Journal of Innovation Management, 14 (3), 278-302.

Halme, M., Lindeman, S. & Linna, P. (2012). Innovation for inclusive business: intrapreneurial bricolage in multinational corporations. Journal of Management Studies, 49 (4), 743-784.

Hansen, E.G., Grosse-Dunker, F. & Reichwald, R. (2009). Sustainability innovation cube: a framework to evaluate sustainability-oriented innovations. International Journal of Innovation Management, 13 (4), 683-713.

Hart, S. (1997). Beyond greening: strategies for a sustainable world. Harvard Business Review, 75 (1), 66-76.

Hart, S. (2010). Capitalism at the crossroads: next generation business strategies for a post-crisis world. Upper Saddle River, New Jersey: Pearson Education, Inc., Prentice Hall.

Hart , S. & Christensen, C.M. (2002). The great leap: driving innovation from the base of the pyramid. MIT Sloan Management Review, 44 (1), (51 – 56).

Hart , S. & Sharma, S. (2004). Engaging fringe stakeholders for competitive imagination. Academy of Management Executive, 18 (1), 7-18.

Hollander, E. E. 2003. The noble art of demand shaping: how the tenacity of sustainable innovation can be explained by it being radical in a new sense. GIN International Network Conference on Innovating for Sustainability.

Holmes, S. & Smart, P. (2009). Exploring open innovation practice in firm-nonprofit engagements: a corporate social responsibility perspective. R&D Management, 39 (4), 394-409.

Holton, I., Glass, J. & Price, A.D.F. (2010). Managing for sustainability: findings from four company case studies in the UK precast concrete industry. Journal of Cleaner Production, 18 (2), 152-160.

Hopewell, S., McDonald, S., Clarke, M. & Egger, M. (2007). Grey literature in meta-analyses of randomized trials of health care interventions. Cochrane Database of Systematic Reviews, 18 (2).

Huber, J. (2008). Technological environmental innovations (TEIs) in a chain-analytical and life-cycle-analytical perspective. Journal of Cleaner Production, 16 (18), 1980-1986.

Hunt, C.B. & Auster, E.R. (1990). Proactive environmental management: avoiding the toxic trap. MIT Sloan Management Review, 3, 7–18.

Immelt, J.R., Govindarajan, V. & Trimble, C. (2009). How GE is disrupting itself. Harvard Business Review, (October), 1-11

Ingham, B. (2006). CSR: the wolf in sheep's clothing. Journal of Public Affairs, 6 (August-November), 283-285.

Ioannou, I. & Ody-Brasier, A. (2011). DESSO (A) Taking on the sustainability challenge. DESSO (B) Going forward. London Business School REF: CS-11-029 and REF: CS-11-030.

ISO survey: certifications up by + 6 per cent. http://www.iso.org/iso/home/news_index/news_archive/news.htm?refid=Ref1491. Accessed summer 2012.

Johansson, G. (2000). Success factors for integration of ecodesign in product development: a review of the state of the art. Eco Efficiency 2000: Towards Sustainable Economic Growth.

Johansson, G. & Magnusson, T. (1998). Eco-innovations: a novel phenomenon? Journal of Sustainable Product Design, 7, 7-18.

Joshi, S. (2010). Sustainable and inclusive innovation: strategies for tomorrow's world. New Delhi, India: Confederation of Indian Industry.

Joshi, S., Arora, S., Pamlin, D. & Sinha, S. (2008). Indian companies with solutions that the world needs: sustainability as a driver for innovation and profit. New Delhi, India: Confederation of Indian Industry-ITC Centre of Excellence for Sustainable Development.

Kang, K.C., Place, M.M. & Seyler, D.R. (2009). Developing new products for emerging markets: a competency based approach. https://ritdml.rit.edu/bitstream/handle/1850/11617/DSeylerCapstone11-18-2009.pdf?sequence=1. Accessed April 2012.

Kaval, P. (2011). Measuring and valuing environmental impacts. A systematic review of existing methodologies. London, Canada: Network for Business Sustainability.

Keijzers, G. (2002). The transition to the sustainable enterprise. Journal of Cleaner Production, 10 (4), 349–359.

Klein Woolthuis, R.J.A. (2010). Sustainable entrepreneurship in the Dutch construction industry. Sustainability, 2, 505-523.

Klewitz, J. & Hansen, E.G. (2011). Sustainability-oriented innovation in SMEs: a systematic literature review of existing practices and actors involved. International Society for Professional Innovation Management Conference on Sustainability in Innovation: Innovation Management Challenges.

Kolk, A. & Mauser, A. (2002). The evolution of environmental management: from stage models to performance evaluation. Business Strategy and the Environment, 11 (1), 14-31.

Könnölä, T., Carrillo-Hermosilla, J. & Gonzalez, R. (2008). Dashboard of eco-innovation. DIME International Conference on Innovation, Sustainability and Policy.

Könnölä, T. & Unruh, G.C. (2007). Really changing the course: the limitations of environmental management systems for innovation. Business Strategy and the Environment, 16 (8), 525-537.

Lamming, R., Faruk, A. & Cousins, P. (1999). Environmental soundness: a pragmatic alternative to expectations of sustainable development in business strategy. Business Strategy and the Environment, 8 (3), 177-188.

Larson, A. (2006). Rohner Textiles: cradle-to-cradle innovation and sustainability. University of Virginia, Darden Business Publishing.

Larson, A.L. (2000). Sustainable innovation through an entrepreneurship lens. Business Strategy and the Environment, 9, 304–317.

Lee, D. & Bony, L.J. (2008). Cradle-to-cradle design at Herman Miller: moving toward environmental sustainability. HBS Case No. 607-003: Harvard Business School.

Lee, K.-H. & Kim, J.-W. (2011). Integrating suppliers into green product innovation development: an empirical case study in the semiconductor industry. Business Strategy and the Environment, 20 (8), 527-538.

Lee, K.H. (2009). Why and how to adopt green management into business organizations? The case study of Korean SMEs in manufacturing industry. Management Decision, 47 (7), 1101-1121.

Lent, T. & Wells, R.P. (1992). Corporate environmental management study shows shift from compliance to strategy. Environmental Quality Management, 1 (4), 379-394.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: a paradox in managing new product development. Strategic Management Journal, 13 (Special Issue), 111-125.

Lettenmeier, M., Rohn, H., Liedtke, C. & Schmidt-Bleek, F. (2009). Resource productivity in seven steps: how to develop eco-innovative products and services and improve their material footprint. Wuppertal Institute for Climate Change and Energy.

Lettice, F. & Parekh, M. (2010). The social innovation process: themes, challenges and implications for practice. International Journal of Technology Management, 51 (1), 139-158.

Loorbach, D., Van Bakel, J.C., Whiteman, G. & Rotmans, J. (2010). Business strategies for transitions towards sustainable systems. Business Strategy and the Environment, 19 (2), 133-146.

López-Pérez, M.V., Perez-Lopez, M.C. & Rodriguez-Ariza, L. (2007). The opinions of European companies on corporate social responsibility and its relation to innovation. Issues in Social and Environmental Accounting, 1 (2), 276-295.

Low, M.K., Lamvik, T., Walsh, K. & Myklebust, O. (2001). Manufacturing a green service: engaging the TRIZ model of innovation. IEEE Transactions on Electronics Packaging Manufacturing, 24 (1), 10-17.

Luiten, H., Knot, M. & Van Der Horst, T. (2001) Sustainable product-service-systems: the Kathalys method. Proceedings of the Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing.

Machiba, T. (2010). Eco-innovation for enabling resource efficiency and green growth: development of an analytical framework and preliminary analysis of industry and policy practices. International Economics and Economic Policy, 7 (2), 357-370.

Magnusson, T., Lindström, G. & Berggren, C. (2003). Architectural or modular innovation? Managing discontinuous product development in response to challenging environmental performance targets. International Journal of Innovation Management, 7 (1).

Mani, M., Lyons, K. & Sriram, R. (2010). Developing a sustainability manufacturing maturity model. Proceedings from the IMS Summer School on Sustainable Manufacturing, 311-321.

Maxwell, D. & Van De Vorst, R. (2003). Developing sustainable products and services. Journal of Cleaner Production, 11, 883-895.

McDonough, W. & Braungart, M. (2002). Cradle to cradle: remaking the way we make things. London: North Point Press.

McManus, R.J., Wilson, S., Delaney, B.C., Fitzmaurice, D.A., Hyde, C.J., Tobias, R.S., Jowett, S. & Hobbs, F.D.R. (1998). Review of the usefulness of contacting other experts when conducting a literature search for systematic reviews. British Medical Journal, 317, 1562–1563.

Melnyk, S.A., Sroufe, R.P. & Calantone, R. (2003). Assessing the impact of environmental management systems on corporate and environmental performance. Journal of Operations Management, 21, 329–351.

Mirata, M. & Emtairah, T. (2005). Industrial symbiosis networks and the contribution to environmental innovation: the case of the Landskrona industrial symbiosis programme. Journal of Cleaner Production, 13 (10–11), 993-1002.

Moors, E.H.M. & Vergragt, P.J. (2002). Technology choices for sustainable industrial production: transitions in metal making. International Journal of Innovation Management, 6 (3), 277-299.

Morton, S. & Grayson, D. (2009). Who should head up your corporate responsibility approach? The who and why of finding your head of corporate responsibility. Odgers Berndtson and The Doughty Centre for Corporate Responsibility.

Mulder, K.F. (2007). Innovation for sustainable development: from environmental design to transition management. Sustainability Science, 2 (2), 253-263.

Mulgan, G., Tucker, S., Ali, R. & Sanders, B. (2007). Social innovation: what it is, why it matters and how it can be accelerated. Oxford: Skoll Centre for Social Entrepreneurship, University of Oxford.

Nidumolu, R., Prahalad, C.K. & Rangaswami, M.R. (2009). Why sustainability is now a key driver of innovation. Harvard Business Review, (September), 57-64.

Noci, G. & Verganti, R. (1999). Managing 'green' product innovation in small firms. R&D Management, 29 (1), 3-15.

Nohria, N. & Gulati, R. (1996). Is slack good or bad for innovation? Academy of Management Journal, 39 (5), 1245-1264.

OECD (2010). Eco-innovation in industry: enabling green growth. OECD Publishing.

OECD (2009). Sustainable manufacturing and eco-innovation: framework, practices and measurement synthesis report. OECD Publishing.

Ornetzeder, M. & Rohracher, H. (2006). User-led innovations and participation processes: lessons from sustainable energy technologies. Energy Policy, 34 (2), 138-150.

Partidario, P.J. & Vergragt, P.J. (2002). Planning of strategic innovation aimed at environmental sustainability: actor-networks, scenario acceptance and backcasting analysis within a polymeric coating chain. Futures, 34, 841-861.

Pereira, A. & Vence, X. (2012). Key business factors for eco-innovation: an overview of recent firm-level empirical studies. Cuadernos de Gestion, 12, 73-103.

Petala, E., Wever, R., Dutilh, C. & Brezet, H. (2010). The role of new product development briefs in implementing sustainability: a case study. Journal of Engineering and Technology Management, 27 (3–4), 172-182.

Peters, S.R. & Coles, A.-M. (2006). Strategic innovation in sustainable technology: the case of fuel cells for vehicles. International Journal of Environment & Sustainable Development, 5 (4), 338-354.

Petruzzelli, A.M., Dangelico, R.M., Rotolo, D. & Albino, V. (2011). Organizational factors and technological features in the development of green innovations: evidence from patent analysis. Innovation: Management, Policy & Practice, 13 (3), 291-310.

Porter, M.E. & Van Der Linde, C. (1995). Green and competitive. Harvard Business Review, (September/October), 120-134.

Prahalad, C.K. (2010). The fortune at the bottom of the pyramid: eradicating poverty through profit. Upper Saddle River, New Jersey: Pearson Education, Inc., publishing as Wharton School Publishing.

Prahalad, C.K. & Hart, S.L. (2002). The fortune at the bottom of the pyramid. Strategy and Business, 26, 54-67.

Prasad, V.C.S. & Ganvir, V. (2005). Study of the principles of innovation for the BOP consumer: the case of a rural water filter. International Journal of Innovation and Technology Management, 2 (4), 349-366.

Pujari, D., Wright, G. & Peattie, K. (2003). Green and competitive: influences on environmental new product development performance. Journal of Business Research, 56 (8), 657-671.

Radjou, N., Prabhu, J. & Ahuja, S. (2012). Jugaad innovation: think frugal, be flexible, generate breakthrough growth. Jossey-Bass.

Ramus, C.A. (2001). Organizational support for employees: encouraging creative ideas for environmental sustainability. California Management Review, 43 (3), 85-105.

Ray, P.K. & Ray, S. (2010). Resource constrained innovation for emerging economies: the case of the Indian telecommunications industry. IEEE Transactions on Engineering Management, 57 (1), 144-156.

Ray, S. & Ray, P.K. (2011). Product innovation for the people's car in an emerging economy. Technovation, 31 (5–6), 216-227.

Reay, T., Berta, W. & Kohn, M.K. (2009). What's the evidence on evidence-based management? Academy of Management Perspectives, 23 (4), 5-18.

Reed, K.E. (2002). Everyone takes the field: how 3M encourages employee involvement in promoting sustainable development. Corporate Environmental Strategy, 9 (4), 383-389.

Rennings, K. (2000). Redefining innovation: eco-innovation research and the contribution from ecological economics. Ecological Economics, 32 (2), 319-332.

Rice, J. & Martin, N. (2007). Using biological models to improve innovation systems: the case of computer anti-viral software. European Journal of Innovation Management, 10 (2), 201-214.

Roome, N. (1992). Developing environmental management strategies. Business Strategy and the Environment, 1 (1), 11-24.

Sandström, G. & Tingström, J. (2008). Management of radical innovation and environmental challenges. European Journal of Innovation Management, 11 (2), 182-198.

Sardinha, I.D., Reijnders, L. & Antunes, P. (2011). Using corporate social responsibility benchmarking framework to identify and assess corporate social responsibility trends of real estate companies owning and developing shopping centres. Journal of Cleaner Production, 19 (13), 1486-1493.

Schiederig, T., Tietze, F. & Herstatt, C. (2012). Green innovation in technology and innovation management: an exploratory literature review. R&D Management, 42 (2), 180-192.

Seebode, D., Jeanrenaud, S. & Bessant, J. (2012). Managing innovation for sustainability. R&D Management, 42 (3), 195-206.

Sehgal, V., Dehoff, K. & Panneer, G. (2010). The importance of frugal engineering. Strategy and Business, 59 (Summer), 1-5.

Shrivastava, P. & Hart, S. (1995). Creating sustainable corporations. Business Strategy and the Environment, 4 (3), 154-165.

Simanis, E. & Hart, S. (2009). Innovation from the inside out. MIT Sloan Management Review, 50 (4), 77-86.

Simon, M., Poole, S., Sweatman, A., Evans, S., Bhamra, T. & McAloone, T. (2000). Environmental priorities in strategic product development. Business Strategy and the Environment, 9 (6), 367-377.

Singhal, A., Svenkerud, P.J., Malaviya, P., Rogers, E.M. & Krishna, V. (2008). Bridging digital divides: lessons learned from the information technology initiatives of the Grameen Bank. In: Hockerts, K. & Van Wassenhove, L. N. (eds.), Sustainable development: perspectives from the alumni sustainability roundtable. INSEAD: INSEAD Social Innovation Centre.

Smith, N.C. (2003). Corporate social responsibility: whether or how? California Management Review, 45 (4), 52-76.

Stafford, E. & Hartman, C. (2001). Greenpeace's "Greenfreeze Campaign": hurdling competitive forces in the diffusion of environmental technology innovation. In: Green, K., Groenewegen, P. & Hofman, P. (eds.), Ahead of the curve: cases of innovation in environmental management. London: Kluwer Academic Publishers.

Stubbs, W. & Cocklin, C. (2008). Conceptualizing a "sustainability business model". Organization and Environment, 21 (2), 103-127.

Sukhdev, P. (2012). The corporate climate overhaul. Nature, 486, 27-28.

Taylor, P.L. (2005). In the market but not of it: fair trade coffee and Forest Stewardship Council certification as market based social change. World Development, 33 (1), 129-147.

Thompson, A.W. (2010). Towards sustainability-driven innovation through product-service systems. PhD thesis. Blekinge Institute of Technology, Sweden.

Tidd, J. & Bessant, J. (2009). Managing innovation: integrating technological, market and organizational change. Chichester, UK: John Wiley & Sons Ltd.

Tietze, F., Schiederig, T. & Herstatt, C. (2011). Firms' transition towards green product service system innovators. R&D Management Conference.

Tingström, J., Swanström, L. & Karlsson, R. (2006). Sustainability management in product development projects: the ABB experience. Journal of Cleaner Production, 14 (15-16), 1377-1385.

Tiwari, R. & Herstatt, C. (2012). Frugal innovations for the "unserved" customer: an assessment of India's attractiveness as a lead market for cost-effective products. Hamburg University of Technology: http://www.tu-harburg.de/tim/downloads/arbeitspapiere/Working_Paper_69.pdf.

Tranfield, D., Denyer, D. & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British Journal of Management, 14, 207-222.

Tukker, A. (2004). Eight types of product–service system: eight ways to sustainability? Experiences from SusProNet. Business Strategy and the Environment, 13 (4), 246-260.

Tukker, A. & Tischner, U. (2006). New business for old Europe: product services, sustainability and competitiveness. Sheffield, UK: Greenleaf Publishing Ltd.

UN Global Compact & Rockefeller Foundation (2012). A framework for action: social enterprise and impact investing. Global Compact Office, United Nations.

Van Der Kroft, T.J. (2010). Innovation strategies for the BoP: new venture development at Philips. Unpublished BSc thesis. Eindhoven University of Technology.

Vergragt, P. & Van Der Wel, M. (1998). Backcasting: an example of sustainable washing. In: Roome, N. J. (ed.), Sustainable strategies for industry: the future of corporate practice. Washington, DC: Island Press.

Von Hippel, E. (1986). Lead users: a source of novel product concepts. Management Science, 32 (7), 791-805.

Waage, S.A. (2007). Re-considering product design: a practical "road-map" for integration of sustainability issues. Journal of Cleaner Production, 15 (7), 638-649.

Wagner, M. (2007). On the relationship between environmental management, environmental innovation and patenting: evidence from German manufacturing firms. Research Policy, 36 (10), 1587-1602.

Wagner, M. (2008). Empirical influence of environmental management on innovation: evidence from Europe. Ecological Economics, 66 (2/3), 392-402.

Wagner, M. (2009). The links of sustainable competitiveness and innovation with openness and user integration: an empirical analysis. International Journal of Innovation and Sustainable Development, 4 (4), 314-329.

WCED (1987). Our common future. World Commission on Environment and Development. Oxford: Oxford University Press.

Westley, F., Olsson, P., Folke, C., Homer-Dixon, T., Vredenburg, H., Loorbach, D., Thompson, J., Nilsson, M., Lambin, E., Sendzimir, J., Banerjee, B., Galaz, V. & Van Der Leeuw, S. (2011). Tipping toward sustainability: emerging pathways of transformation. AMBIO: A Journal of the Human Environment, 40 (7), 762-780.

Winn, M.I. & Angell, A.C. (2000). Towards a process model of corporate greening. Organization Studies, 216, 1119–1147.

Winn, S. & Roome, N. (1993). R&D management responses to the environment: current theory and implications to practice and research. R&D Management, 23 (2), 147-160.

Wymer, W. & Samu, S. (2003). Dimensions of business and nonprofit collaborative relationships. Journal of Nonprofit and Public Sector Marketing, 11 (1), 3-22.

Zeschky, M., Widenmayer, B. & Gassmann, O. (2011). Frugal innovation in emerging markets: the case of Mettler Toledo. Research-Technology Management, 54 (4), 38-45.

Zhou, J., Tong, Y. & Li, J. (2011). Disruptive innovation in China's BoP market. In: Kocaoglu, D. F., Anderson, T. R. & Daim, T. U. (eds.), 2011 Proceedings of Picmet 11: Technology Management in the Energy-Smart World.

Zhu, Q., Sarkis, J. & Lai, K.-H. (2011). Green supply chain management innovation diffusion and its relationship to organizational improvement: an ecological modernization perspective. Journal of Engineering and Technology Management, 29 (1), 168-185.

about NBS

A Canadian non-profit established in 2005, the Network for Business Sustainability produces authoritative resources on important sustainability issues – with the goal of changing management practice. We unite thousands of researchers and professionals worldwide who believe passionately in research-based practice and practice-based research.

NBS is funded by the Social Sciences and Humanities Research Council of Canada, the Richard Ivey School of Business (Western University), the Univiersité du Québec à Montréal and our Leadership Council.

This research was funded in part by the Social Sciences and Humanities Research Council of Canada.

Social Sciences and Humanities Research Council of Canada | Conseil de recherches en sciences humaines du Canada

NBS Knowledge Centre

Read other NBS Systematic Reviews:

- Embedding Sustainability in Organizational Culture
- Decision-making for Sustainability
- Building Effective Environmental Policy

Feedback

Please let us know what you thought of this report. Contact NBS at info@nbs.net.

NBS Leadership Council

NBS' Leadership Council is a group of Canadian sustainability leaders from diverse sectors. At an annual meeting, these leaders identify their top priorities in business sustainability – the issues on which their organizations need authoritative answers and reliable insights. Their sustainability priorities prompt each of the NBS's research projects.

NBS Leadership Council members are not responsibe for the content of this report.

Network for
Business Sustainability

Business. Thinking. Ahead.

Network for Business Sustainability
c/o Richard Ivey School of Business
Western University
1151 Richmond Street
London, Ontario, Canada N6A 3K7
519-661-2111 x88980

Réseau entreprise et
développement durable

Penser l'entreprise en visionnaire

Réseau entreprise et développement durable
École des Sciences de la gestion
Université du Québec à Montréal
1290, rue Saint-Denis, 6e étage, AB-6270
Montréal, Québec, Canada H2X 3J7
514-987-3000 x7898

nbs.net