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Value Networks in Manufacturing

Sustainability and Performance Excellence

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This book is dedicated to the R&D team of the EU Project 'SustainValue', their beloved families, and affiliations for continuous commitment, creativity, and teamwork.

Preface

The significance of the manufacturing industry in Europe is widely known and accepted. Manufacturing companies generate, directly and through services, wealth and jobs in all European countries. Globalization has activated a novel industrial revolution, leading to a new world wide distribution of production and markets. The increasing demands for sustainability, at the same time, have created new challenges and emerging opportunities for society and for business. The traditional trans-national manufacturing product and service delivery solutions cannot be sustained in business environments, where growing trade volumes and commercial operational patterns impose significant environmental challenges across Europe. Hence, a radical shift is required, with industry being in a key position to pursue sustainable consumption and production solutions.

Much of the opportunity to address sustainability rests on enhanced network management. Leading companies are looking for new approaches to manage sustainability impacts effectively. If manufacturing network partners do not manage the future challenges around regulation, reporting and compliance assurance, scarcity of resources, or the effects of climate change on their business, then their ability to operate as a network partner could be dramatically affected. This could be fatal to their business.

To be successful in this changing business environment, manufacturers must be pro-active. Industrial practitioners need to be creative in recognizing the opportunities that the sustainable economy will present for the development of new products, the identification of changes in markets, and for optimizing their operating network.

Enterprises must take into consideration not only the economic goals but also the need to meet environmental and social goals in conducting business, recognizing that economic, environmental and social impacts occur at all stages in the value network. This requires managing the internal activities and operations of the producing organization and ensuring that all value network partners follow the same principles and performance standards that have an influence on the sustainable product and service delivery performance. Sustainable value creation is the key contribution of enterprises to sustainability, i.e. to create long-term environmental, social and economic value. Individual businesses cannot deliver the system changes required at the value network level. Collaboration among partners can and must be enabled by developing attractive and common approaches for sustainable production and services.

The existing business models are mostly based on creating, delivering and capturing economic value for customers and shareholders, with limited or no attention paid to environmental and social value and a broader range of stakeholders. These traditional business models are based on linear industrial models that externalize environmental and social impacts. These cannot support the sustainable business creation that is required to meet the future needs of the planet and of increasingly discerning customers, who want features other than economic value.

Where environmental and social value has been created by firms, it is often through compliance with regulations or corporate social responsibility programs. While important, these approaches have not generally embedded sustainability into the core of the business, and as such their impact is often limited. The changing business environment, wider range of stakeholders engaging in the debate over industry, resource limitations and the emphasis on the social responsibilities of firms have raised the need for business model innovation to integrate sustainability more fully into the core of the business.

The above observations demonstrate the importance of providing tools and methodologies to maximize sustainability in companies, showing how the business can be improved by using sustainable guidelines. It also emphasizes the importance of doing this at the network level, as the impacts do not mainly occur inside the final Original Equipment Manufacturer (OEM) business. Nevertheless, OEMs are key players because they specify designs and materials, select suppliers and co-ordinate networks.

Sustainability is becoming a central factor in companies' long-term competitiveness and working in this way will affect their value networks. The involved business partners are integrated within several networks, making planning, coordination and management a tedious and challenging task. The decision making setting in particular brings challenges due to the decentralized nature of business decisions and operational activities. In this context, a major impact on the networked production environments could be achieved through holistic and integrated solutions for the sustainability of complex value networks, rather than through isolated or ad hoc solutions.

This book is based on the results of the *SustainValue* (*Sustainable Value Creation in Manufacturing Networks*) project, which was a small-scale collaborative project within the EU 7th Framework Programme. This three-year project began on April 1, 2011 with a total budget of 4 million euros, of which the funding from the European Commission was 2.8 million euros. The overall aim of the project was to develop industrial models, solutions and performance standards for new sustainable and higher-performing production and service networks. In principle, it aimed at:

1. enhancing governance and business models that enable the active integration of dynamic and complex production systems working towards cooperative and sustainable value-adding business networks,
2. simplifying the adoption of sustainable approaches, business models and solutions providing sustainability and performance KPIs together with guidelines for implementation,
3. delivering a new methodology that supports sustainable, competitive and customer-oriented life cycle decisions on products and services in complex production systems,
4. supporting compliance verification processes for continuous improvement by developing sustainability assurance performance standards for complex business processes in integrated production and service networks.

This book brings various important perspectives into spotlight, together with a number of techniques and methods that can help support the manufacturing sector to explore new avenues in economic, social, and environmental terms in emerging networked business environments.

Stavanger, Norway — Jayantha P. Liyanage
Tampere, Finland — Teuvo Uusitalo

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Contents

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He is actively involved in a number of R&D and joint industry projects over the last decades both at advisory and managerial capacities, and has published more than 100 publications. He is an editorial reviewer and a member of international editorial boards of a number of international journals and the editor in chief of International Journal of Strategic Engineering Asset Management (IJSEAM).

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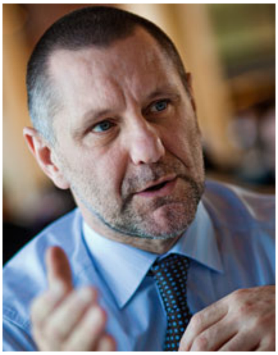

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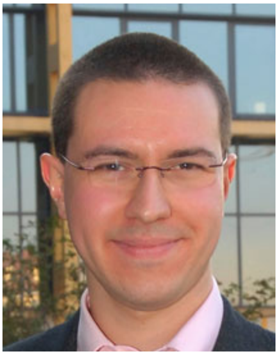
Professor Evans spent 12 years in industry, finally as Engineering Systems Manager at Martin-Baker Engineering, the world leading manufacturer of ejection seats. He became professor of Life Cycle Engineering at Cranfield University in 1998 and joined the University of Cambridge Institute for Manufacturing in 2011. He is director of the national EPSRC Centre in Industrial Sustainability conducting research into how industry can bring ambitious environmental and social sustainability goals into practice.

Steve has acted as specialist adviser to the House of Lords, as a member of the Lead Expert Group for the Government's Future of Manufacturing Foresight exercise setting out a vision for UK manufacturing to 2050 and other policy roles. He is the chairman of the Manufacturing Policy Panel for the Institution of Engineering and Technology and a fellow of the Royal Society Arts and Commerce. He is a partner or founder of four clean technology start-ups.

Steve is an action researcher who works with many companies around the world to improve their sustainability performance. His research seeks a deep understanding of how industry might change, with a dual emphasis on urgent and practical change now and system-level change that offers hope for a sustainable future.



Luca Fumagalli is a mechanical engineer, and he has collaborated with the Department of Management, Economics and Industrial Engineering (DIG) of Politecnico di Milano since January 2007. In 2010, he completed the Ph.D. programme, and from 2015, he is an assistant professor at Politecnico di Milano. He works on different research topics about production management, industrial services and in particular maintenance management-related topics, with a specific concern on new technological solutions. His research activity has been related also with European research funded projects. Luca Fumagalli is also presently responsible of the research of the observatory TeSeM (www.tesem.net) and vice-director of Master Megmi (Master Executive in Gestione della Manutenzione Industriale—Executive Master on Industrial Maintenance Management) delivered by MIP—School of Management—Politecnico di Milano and SdM—School of Management Università degli Studi di Bergamo (http://www.mip.polimi.it/megmi)

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Part I
Introduction

Living with Complexities and Uncertainties

Jayantha P. Liyanage

1 Introduction

In the modern global setting, a number of complex issues play a pivotal role in shaping the global economy at large. Both opportunities and vulnerabilities are expected to grow subsequently as more countries and industrial sectors seek aggressive development. Despite the fact that market share has a dominant impact on the modern corporate economy, environmental concerns, price volatility, supply insecurity, etc. have begun to shape up a change that gradually creates a global risk mix. In an attempt to respond to market realities, some of the global corporate giants have begun to transform into *value networks*, making a strategic move to stay competitive.

It is clear today that innovation will highly regulate the competition for at least the next 20–30 years or so. The economic intensity of such new conditions and role in wealth creation have introduced inevitable impacts that will have ramifications across various social, political, economic and technological institutions. Various forms of innovations (e.g., business, process, product, service) also feed external institutions and societies with extra investments for research and development, improved technologies and infrastructure, social programs, professional development activities, etc., creating new opportunities. This, in conjunction with other sensitive issues (e.g., environmental sensitivity, resource consumption, risk exposure), keeps new business models such as value networks as a competitive option in the modern global industrial environment. Presumably, over the next few years, major political and economic decisions will profoundly be impacted simply by supply and demand patterns across different sectors and by supply and demand behaviors between different regions. Even today, some of the influential corporations are positively inclined to review their business policies and operations to

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manage hidden risks and to capitalize on opportunities based on strategic network principles.

With escalating uncertainties, deregulating markets, spin-offs, new forms of risks, etc., the rules of the game have apparently been redefined in various businesses. Competition is further intensified in the wake of limited resources, more marginal prospects, market demands, etc. Moreover, mergers and acquisitions that swept across the industry on a massive scale resulted in the clear market dominance of many organizations, while others still strive to remain competitive, particularly in the event of substantial profit downturn during a period of economic recession. Rapid cost cutting, downsizing, and subsequent restructuring were widely seen as the panacea to overcome obvious threats to survival. In spite of the short-term savings secured by resorting to quick solutions, the long-term consequences are as yet uncertain. In the longer term, there are known repercussions of cost-cutting and downsizing decisions, and as Stultz-Karim (1995) notes, becoming leaner and meaner does not necessarily mean that those organizations have become progressive. In the face of escalating uncertainties and risks, industry in general appears to have adopted a relatively cautious strategy to secure added value.

In the continuous confrontation with this dynamic, uncertain, and complex business environment, the leaders of organizations seem to have understood that the form of the game has changed and it is necessary to take a different stance. Change mostly presents various challenges. Thus, many analysts question whether mere financial strength, size and scale of operations, and diversified portfolios alone are sufficient to gain commercial success tomorrow (e.g., see Stultz-Karim 1995; Tomei 1998; Bradely and Hartog 2000; Fanchi 2000; Agbon 2000; Malin 2000; Arnold 2000; Pearson 2000; Daneshy 2000; Armstrong 2000 etc.). With growing economic concerns still in the air, organizations have begun to understand that a substantial share of business success today is constituted of intangibles (e.g., knowledge, alliances, cooperation, image and reputation etc.) and other forms of strengths and that they should be able to exploit these at the best possible price (see, for example, Gaddy 2001). This signals that a business needs to develop new perspectives and to resort to novel management frontiers in order to sustain profitability and growth. This, in principle, underlines a message that it is critical to adopt a dynamic performance management practice that appreciates non-financial aspects and capitalizes on intangibles, institutional knowledge, etc., to sustain competitivity by fulfilling critical stakeholder expectations. There are many drivers that make these transitions quite compelling and continuously rolling.

More today than ever, exceptional business performance is heavily dependent on the extent of business intelligence possessed by individual organizations. The nature of intelligence required for strategic corporate planning and operations and to secure value-added in principle rests on a deeper understanding of:

- what forces shape the competition in global industry,
- what is the emerging business setup,
- what corporate vision and business model would fit the future.

Ideally, this should allow an organization to continuously match its resources and competencies with the emerging business environment. This should encompass various strategic choices, where the leadership adopts the best business model and transforms it into a set of deeds through decision-making processes, indicating the most favorable responses to governing circumstances. This can eventually generate a complex mix of both aggressive and smooth operations resulting from offensive and defensive decisions.

2 Force Field

In response to various forms of forces, both market and institutional, organizations in general are inclined to modify their underlying management models or templates that guide their decisions and activities in order to remain competitive (Porter 1985; Richard 1992; D'Aunno et al. 2000). The theoretical underpinning is that there is a continuous interaction between organizations and the environment in which they exist, as those organizations act as open systems, sensitive to changes and events. It implies that there is an inherent relationship between environment, strategy, and performance (Thompson 1997; Luo and Park 2001; Prescott 1986). For instance, in most host communities around the world, protests from local community organizations on environmental pollution and economic accusations are making it impossible for organizations to operate without engaging in social engineering or economic development activities. Individual organizations in diverse business sectors evolve according to their leadership and its response to such forces and changes in the markets and other business environments that it serves (Agbon 2000; Abbott et al. 2001). While exploring the managerial models that have been adopted by major players under these circumstances, it is worthwhile initially to understand what drives such a change or what forces and scenarios can probably be instrumental in articulating turning points of the common future of businesses.

In general, all the businesses around the world are continuously exposed to diverse forces. PricewaterhouseCoopers (2002) identifies six such generic forces that affect all industrial conditions, namely customers, e-business, knowledge, reporting and transparency, attracting the talent, and political landscape. Apparently, a part of the pressure is based on the statutory, regulatory, and fiscal regimes, and the other emerges from changes within political, financial, and social institutions inclusive of NGOs. In addition, competition has become more aggressive, posing challenges in terms of market capitalization, exploitation of resources, and access to intellectual capabilities. The situation is further intensified by technological innovations, spin-offs, etc. The stream of market signals received from time to time from highly successful companies portrays various changes in the core business philosophy and thus corporate behavior. These are particularly embedded in policy statements, corporate publications, media coverage, public speeches, etc. Those sources, coupled with other literatures (e.g., Armstrong 1994; Stultz-Karim 1995; Browne 1998; Tomei 1998; Bradely and Hartog 2000;

Abbott et al. 2001; Sprunt 2001; Garcia and Vredenburg 2002), provide voluminous evidence about existing conditions and the chain of reactions by the major players in business. Continuous review of information from such sources indicates what constitutes the current *force field* that can strongly shape the future of businesses (see Table 1).

The intensity of the impact of the force field on commercial success is largely influenced by business strategies and behavior adopted by individual organizations. Obviously, there is a wide array of strategic choices available to different organizations to confront these challenges. Not all such choices are of course appropriate and feasible for every individual organization, but specific selections are largely dependent on a particular organization's interests, needs, priorities, and capabilities. However, in general, the way corporations conduct their business internationally has been changing, and organizations are approaching different management strategies in order to operate more sensitively than before (Armstrong 1994; Garcia and Vredenburg 2002).

Table 1 The major components of the force field for businesses

Stakeholder expectations Expectations are greatly enhanced as a consequence of informed societies, far-reaching knowledge, growing social campaigns, standards of living and quality of life, coupled with the respect for global diversity, demand for higher standards, greater choice, better value, etc.
Industry condition This is largely dependent on the magnitude of globalization, mergers and acquisitions, the liberalization of markets, regulatory pressure, etc., coupled with global warming, advanced technologies, rapid structural changes, spin-offs, volatile oil price, sociopolitical and economic policies, etc.
Global demographics There is a direct impact of population growth, rapid industrialization and urbanization and its subsequent demands, and business accountabilities on socioeconomic development, coupled with supply security, environmental concerns leading to alternative solutions, and a focus on future well-being
Resource exploitation Situations are influenced by aging systems and infrastructure, rapid industrial development in environmentally sensitive and risky areas, coupled with resource intensity for commercial activities, increasing competition for limited resources and new forms of risks that those activities and organizations are exposed to
New competence compilation This is dependent on the other four components subsequently demanding better economic stability and new forms of competence, for instance within the human, technological, social, and managerial fields, to remain competitive

3 Perceptions of the Future

The greater the competition, the higher is the need for competitors to foresee the future as being proactive. Scenarios have been used in this context to actively develop strategies for long-term business advantage, by addressing the unknown future and its potential impact on businesses. It combines strategic thinking, deeper context, and meaningful expressions of the future and subsequently helps businesses to prepare for major changes ahead by allowing them to link uncertainties to decisions.

The *World Business Council for Sustainable Development* (2001) has developed an interesting global scenario of business impact, as illustrated in Table 2.

However, strategic planning to confront the undefined future is very much dependent on the users' perception about what is important, how those elements would evolve in the future, and linkages between elements in shaping the forces in the environment. In the current and emerging business environment, environmental and social demands gradually become more stringent and influence competition. Together with other increasing demands, these issues pose various risks and uncertainties for industry. However, they also present significant opportunities and advantages to organizations which are ready to see and pursue them (Browne 1998; Armstrong 1994). Organizations just have to learn how to translate this change into a means of developing various competencies that create competitive advantage. To stay ahead in the rapidly evolving new era, it is necessary to resort to such continuous learning and improvement processes. This obviously involves an element of thinking globally (i.e., gathering business intelligence) to act locally (i.e., deploying offensive and defensive strategies) to remain competitive. For instance, it is known that the success of various types of projects is increasingly dependent on achieving

Table 2 Global scenarios based on WBCSD

Global scenarios 2000–2050, based on WBCSD (World Business Council for Sustainable Development 2001)
The WBCSD (World Business Council for Sustainable Development) Global scenarios 2000–2050 are centered around three principal concepts (i.e., *FROG, GEOPolity*, and *JAZZ*), defined with reference to the triple effect of: • *the new* (social change and technological innovations, new economy, and new era of human history) • *the many* (increase in people accompanied by an increase in the diversity that influences how societies and economies are shaped and what decisions are made) • *the connected* (the global 'technosphere'—a combination of technology, economy, and society—to rival the global ecosystem) The complex interconnection between them is consequential to the divergence from FROG (i.e., 'unsustainability' with narrow economic myth) to GEOPolity or JAZZ (i.e., toward 'sustainability' with evolving or competing economic myths)

endorsement from local communities and other stakeholders who are concerned about business operations. Such a responsible approach will enable organizations to contribute credibly to the public debate and to work constructively to avoid unnecessary business risks. Furthermore, in order not to fail in good business prospects, organizations have become much more cautious than they used to be (Abbott et al. 2001). They tend to explore potential pitfalls deeply and to identify all possible stakeholders from the onset (Tomei 1998; Bradely and Hartog 1998), as they *perceive the change in the periphery.*

In principle, the ongoing change is apparently driven by:

- global transformations,
- social and stakeholder power,
- changes in the ecosystem.

These, by large, are the cornerstones that shape the business environment and the norms and principles of business conduct. A significant effort is likely to be necessary if industry is to maximize benefits and to minimize risks posed by current movements (Bradely and Hartog 1998; Armstrong 1994). This inherently involves an organizational learning process, and, say Argyris and Schon (1978), organizations are dynamic systems which have the capacity to learn and to become more open in terms of acknowledging realities about them and their environment. This importantly showcases a strategic link between the development and deployment of the dynamic capabilities of an organization and cohesive actions to realize competitive strategies and policies. For instance, according to Teece (1998):

> Dynamic capability is the ability to sense and then to seize new opportunities, and to reconfigure resources, competencies, etc. to achieve competitive advantage.…such sense-making or interpretation is a critical function as it enables the organization to connect with its environment where the subsequent decisions will be based upon hunches and informed guesses about the true state of the world…this sense-making can be assisted by scenario planning that helps managers develop mental maps of possible complex future realities. The object is not to predict the future, but to understand the fundamental drivers of change and to quickly chart action plans. (Teece 1998, pp. 72–74)

This makes adequate allowances for organizations to be *proactive–dynamic* (Sudhir and Murthy 2001) or *sense-and-respond* types (Hope 2000), as opposed to *reactive–static*.

4 New Demands in Perspective

A recurrent criticism against many organizations is that relatively little time is allowed for addressing complex and sensitive issues. Increasingly, issues such as human rights, sustainable economic development, corporate responsibility, international standards, fairness, social justice, the rights of indigenous people, and environmental conservation are being raised (Tomei 1998; Bray 1999; Garcia and Vredenburg 2002). Further, Agbon (2000) contends that the current economics of production are purely profitable from the perspectives of organizations, governments, and shareholders but not necessarily so from the viewpoint of host communities and other types of stakeholders. This may be attributed, for instance as research shows, to the fact that organizations in general tend to display a different attitude toward economically weak stakeholders (Unerman 2000). However, there is an uprising social vigilance on the performance of organizations. If organizational performance is perceived as discriminate and prejudicial, then there is a high risk of rising disruptions to business activities by host communities in various forms (e.g., Myanmar, Nigeria, Argentina, Alaska, and Canada). Such increasing disruptions and their direct impact on the economics of business ventures have forced production, manufacturing, and process industry to cautiously evaluate their relationships with stakeholders. As Tomei (1998) observes, owing to principles, requirements, and responsibilities related to compensation, rehabilitation schemes, or dispute settlement procedures over compensation for injuries, several organizations have adopted measures to minimize social conflict and adverse social and environmental impacts. In this process, industries have to firstly define their own role for effective participation in a sustainable change process and secondly draw up proper strategies to adapt that would allow them to protect the credibility and security of activities to ensure that there is a shared payback (Armstrong 1994; Browne 1998).

The principle is to innovatively explore what type of strategic planning is required to adapt successfully to the emerging conditions and thus to sustain long-term business competitivity. Such a process must stay in tune with key trends and major forces to be early prepared to take advantage of them. Hence, it inherently involves, notes Mintzberg (1994), *analysis* (i.e., learning from all sources) and *synthesis* (i.e., exploitation of learning to develop a vision of the direction that the business should pursue). In this process, one must continue to ask not just whether *we are doing things right* but also whether *they are the right things to do* (Abbott et al. 2001). In many cases, this may constitute a paradigm shift in the way the business is conducted, which can lead to radically new and more exciting business practices with an understanding that the emerging environment for business exposes organizations to a complex profile of opportunities and risks. For instance, according to Smith (1998), Abbott et al. (2001), etc., increased focus on management of risks, or integrated risk management, and in addition, compliance-based actions prompted organizations to begin looking more closely at the social and other forms of risk issues impacting their business. It is this shift toward broader risk-based approaches, new management agendas, and ecoaccounting that provided the thinking and discipline necessary for evolving to another stage of a business. Even the ability itself to transform, as Armstrong (1994) underlines, to a very great degree defines their long-term business viability. Moreover, the prevailing business environment seemingly has provided favorable conditions and thus is relatively fertile to make this transition. Transition pressure can come from various sources, ranging from scientific evidence, legislation, shareholders and new investors, and local communities, to costs of resources, waste disposal, decommissioning and pollution, the market, cost of insurance, etc. (Stultz-Karim 1995; Smith 1998). It also manifests a range of issues that define the context in which business has to be conducted. The present business intelligence appears to have largely understood that while profitability is essential for continuity of business, society is demanding that companies should be accountable for more than just financial performance to remain successful. Then, interestingly, the definition of management seems to be gradually evolving as a process that strategically as well as dynamically balances *value creation* and *risk mitigation* under relatively complex and uncertain conditions.

5 From a Complex Picture to Instrumental Elements

As the world's demand continues to grow year by year, a blend of outstanding human skills, technological innovation, global outreach, and strong relationships with stakeholders has apparently become requisite for commercial success of any business. In response to greater scrutiny from social, political, and regulatory institutions, and in recognition of the wider economic, social, political, and even ecological impact of decisions and actions, businesses appear to recognize that success is not just an issue of superior financial achievements but is also dependent on the impact of a multitude of stakeholders over a wide area of performance. A majority of top performers appear to insist that an explicit transition in business management policies is impetus to sustain long-term profitability and growth. In addition, the series of economic turbulences, which have occurred over the last two decades along with modern uncertain conditions, have prompted almost all industrial sectors to perform a critical review of business strategies and practices. The overall approach has been to examine carefully every facet of business operations, resulting in new ways of doing business. Varied perspectives, drawn toward new types of risks that companies are exposed to, have greatly motivated this further. In essence, current status has stimulated a debate and recognition of the criticality of responsible and accountable business performance as a smart risk reduction and an opportunity exploitation strategy. This in principle underlies at least five major corporate behavioral traits:

- *a worthy 'license holder'* (efficient use of local resources, expansion of economic activity in the operating region, correct business attitude, respect, and cater to local needs and demands),
- *a strong competitor* (create value and manage risk through a stronger business standard, respect market ethics and dynamics, etc.),
- *a responsible partner* (stimulate business activity, compete ethically, respect mutual profits and growth strategy, efficiently develop local supply chains, service sectors and infrastructures in order to develop and grow business, no harm through activities, etc.),
- *a good corporate citizen* (bring sustainable benefits to the people, improve quality of life, create opportunities, display legitimate conduct, etc.),
- *a good neighbor* (be a role model, seriously take into account community growth, immediate environmental impact, social progress, etc.).

Despite the fact that actual performance behaviors of organizations can be attributed to diverse reasons (e.g., social norms, peer influence, neighborhood effects, imitation), the principal stimuli of such behaviors are common conditions and characteristics in external environments (Granovetter 1979; Manski 2000). The apparent transition in business practices also embodies a change in managerial philosophy to embrace *corporate social responsibility* and/or *sustainable business* that transcends a synthesis of *economic, social*, and *environmental* performance (Fig. 1).

Despite notable differences in some aspects, there is a growing management recognition across industry that decision criteria and course of action should favorably promote a commitment to sustainable business. For instance, the emerging criteria adopted for investment decisions by top competitors are not said to be exclusively economic in nature but also have serious social and environmental considerations in the appraisal of investments, new projects, modifications to existing assets, and so on (see, for instance, Jones et al. 1996; Bradely and Hartog 2000; Hargis 2000; Agbon 2000; Wolff et al. 2000). There are some novel methods and tools that have been developed to support this process, including *Ecological and Developmental Assessment Model* (Waible et al. 1996), *Sustainable Development Risk Assessment Tool* (Abbott et al. 2001), and *Sustainable Development Assessment Checklist* (Bradely and Hartog 1998). In respect of these developments, there is a general move toward challenging the business community to adopt suitable dynamic strategies to cope with emerging vibrant industrial conditions.

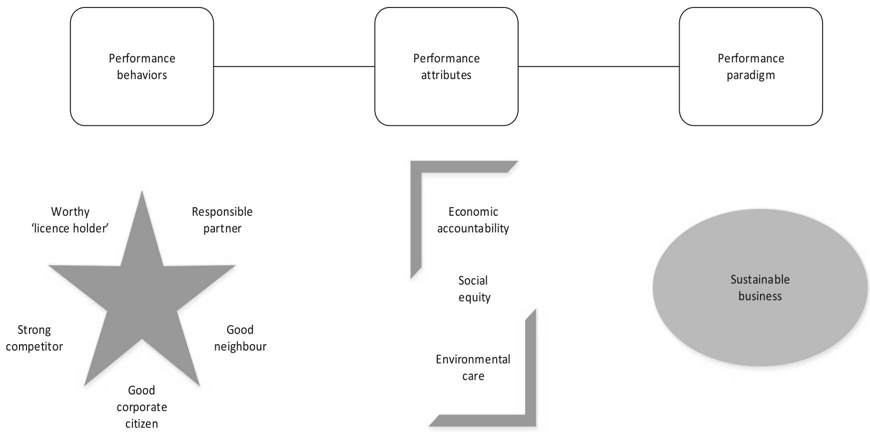

Fig. 1 Major performance traits in the global business environment

6 Question of Life

In an era where the sociopolitical environment demands a detachment from pure profit-seeking to more legitimate and value-adding business activity, and where new forms of risks and opportunities emerge due to market and industrial transformations, it is a critical challenge for many industrial sectors to decide which policies and principles best suit them to survive and succeed. During the change process, many policies have been drawn up, many initiatives have been taken, many words have been spoken, and many stipulations have been made from various parts of the public and private sectors. However, notably,

> There is no place to hide in today's interconnected world. A good reputation can therefore basically only be created and maintained by results. Talk is no longer cheap. Words have consequences. Corporations must walk the talk. Otherwise they will have to pay. (*A former CEO of Statoil, at the World Petroleum Congress: Calgary: 14th June 2000. Source* www.Statoil.com)

The interest, attention, insight, and influence of the world at large are too great to sustain discrepancies between word and deed. Corporate behavior will speak for itself, and the price that the corporate players risk having to pay for irresponsible behavior, illegitimate conduct, and, thus, lost reputation, can be too great to bear under the complex and uncertain conditions of the emerging world.

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Sustainability Concept and Complex Performance Dimensions

Jayantha P. Liyanage

1 Introduction

The business principles of *corporate social responsibility* represent a fine blend of profits and fundamental social-oriented principles: principles that emerged as consequences of rapid globalization requiring a sensitive balance between businesses, governments, and societies at large. It covers a range of organizational interactions with society that varies from health, safety, and environmental protection to conditions of employment, industry and labor standards, social development and human rights, etc. It is believed to play an effective role as a strategy that fits with challenging industrial circumstances to gain competitive advantage. In the present context of business applications, the distinction between corporate social responsibility and *sustainable business* is that while the former rests on the societal impact of corporate performance, the latter seeks a blend of economic prosperity, environmental quality, and social equity, capturing a much broader scope and presenting a composite picture of a legitimate business.

Sustainability movement has captured global attention since 1987, following the World Commission Report on Environment and Development, entitled *Our Common Future*, which offered a vision of achieving sustainable economic growth and high environmental quality through good business practice (UN Department of Economic and Social Affairs 2001). Sustainable development is defined in that report as a strategy:

> that meets the needs of the present generations without compromising the ability of future generations to meet their own needs.

Interestingly, the UK government's definition of sustainable development seems to have taken the path of *quality* in business sense. It is described as (Department of Environment, Transport and the Regions 1999):

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> the simple idea of ensuring a better quality of life for everyone, now and for generations to come.

However, just as these definitions are more abstract, the term 'sustainable business' appears to have been embraced in different manners. For instance, Hargis (2000) defines it more narrowly as a relatively constant level of production in a defined geographic region over an extended period of time. Looking at it more holistically, Browne (1998) defines it as business or other activities that have the ability to continue indefinitely, with minimal depletion of natural resources or damage to the host ecosystem and with a contribution to the improvement of social equities and local economies. Viewing sustainable business more from a business perspective, Garcia and Vredenburg (2002) advocate adopting business strategies and activities that meet the needs of enterprise and its stakeholders today, while protecting, sustaining, and enhancing the human and natural resources that will be needed in the future. In general, the principal emphasis here is on the simultaneous meeting of a fourfold objective:

- social progress which recognizes the needs of everyone
- effective protection of the environment
- prudent use of natural resources
- maintenance of high and stable levels of economic growth.

In addition, some major issues related to sustainability movement have also been addressed in terms of *ecologically sustainable business, corporate greening, eco-accounting, environmentally sustainable human activity, organizational ethical and moral strategies*, etc. (see Smith 1998; Winn and Angell 2000; Soule 2002; Somers 2001; Wilmot 2001, etc.)

2 Moving with the Flow

The move toward sustainability has begun to gradually gain a significant position in political, business, and societal agendas, resulting in the growth of an integrated perspective on this issue. In a business context, more organizations were exposed to the concept as a competitive business approach after the report entitled *Changing Course* was prepared by the Business Council for Sustainable Development (UN Department of Economic and Social Affairs 2001) for the United Nations Conference on Environment and Development (UNCED). This primarily emphasizes the balance between the short term and long term, as well as the integration of the economic, environmental, and social aspects of the business to make good business sense. As a former Chairman of Royal Dutch Shell emphasized:

> Excellent environmental performance is meaningless if no wealth is created. Wealth in a destroyed environment is equally senseless. No matter how wealthy, a society fundamentally lacking in social equity cannot be sustained. (Moody-Stuart 2000)

Interestingly, not only are social and political institutions concerned about sustainable businesses, but financial institutions (example, *Dow Jones Sustainability Index* (DJSI)) are also seemingly keen on what are termed *sustainable investments*. DJSI was launched in September 1999 (Dow Jones Indexes 2001), with an intention to track the performance of companies that are leaders in sustainable development; it currently features more than 200 of the most sustainable top performers in 68 industries with a substantial market capitalization. The Index emphasizes that:

> Increasingly investors are diversifying their portfolios by investing in companies committed to corporate sustainability. A company's pursuit and management of sustainability opportunities and the reduction and avoidance of sustainability risks and costs also facilitates the financial quantification of corporate sustainability performance. Sustainability leaders can be identified and ranked for investment purposes according to their management of sustainability opportunities and risks.

It counts on fivefold performance principle that allows a company to manage opportunities and risks competitively:

- innovation (product and service innovation with efficient use of resources)
- governance (higher standards with quality, responsibility, capability, and culture)
- shareholders (short-term and long-term focus, competitivity, and intellectual capital)
- leadership (best practice and superior performance)
- society (well-being and stakeholder engagement).

A similar investment move has stemmed from *Environmental Enterprise Assistance Fund* (see Browne 1998), which has developed mechanisms to support the growth of indigenous private sector enterprises by creating venture capital funds. These funds invest only in businesses that meet strict environmental and economic goals and are supported by the capital of other investors such as the World Bank. Investors are allowed by these funds to manage their demands driving market changes with greater environmental and social sensitivity.

These initiatives aim to boost investors' interests in *sustainability investments*, i.e., investing in companies prioritizing environmental and social concerns alongside economic results by showing that they often outperform the market average. Several financial institutions from various countries (e.g., Germany, the Netherlands, Switzerland, and Norway) are said to have already started to set up their investment funds based on the DJSI index, also gaining interest from investment communities (e.g., in Scandinavia and the UK) (Environment News Service (ENS) 2001). For instance, a rapid growth in *Socially Responsible Investment* (SRI) funds (or sustainable investments) has been reported in recent years, which is said to have risen from \$2 trillion in 1999 to \$3 trillion in 2001 in the USA alone (Gilmour and Caplan 2001). In the UK, such investments in *ethical unit trusts* have amounted to £3.3 billion (Hayward 2002). Furthermore, Albinger and Freeman (2000) report an increment in socially screened investment portfolio holdings, as announced by the *Social Investment Forum*, from $639 billion in 1995 to $1.185 trillion in 1997. This shows the growing attention of investors not only on how much profit has been made but also on how it has been generated. Current evidence shows that these actions influence the investment decisions of business leaders who use references such as DJSI as objective benchmarks for sustainability portfolios. Subsequently, the Dow Jones reports that the average sustainability performance of companies has improved significantly. Moreover, as an Editor of Dow Jones Indexes once underlined:

> People realize that sustainability trends have an important impact on the companies they invest in. Moreover, recent corporate scandals have emphasized the need for greater transparency and accountability. As a result, an increasing number of investors is turning to the concept of sustainability to identify well-managed and future-oriented companies. (Prestbo 2003)

Particularly for IPO (Initially Public Offering, i.e., those who are listed on stock markets) organizations, these sustainable investment decisions cannot be ignored. For instance, according to Barry (1994), Lerner (1994), in addition to providing capital for development, venture capitalists add value to organizational performance through their screening, monitoring, and decision-support functions. Hence, their activities, in addition to an infusion of capital, are important for organizations' survival profile and competitivity. As such, those capitalists or their alliances have the ability to influence the actions of managers as well as of external market participants such as institutional investors, investment bankers, and analysts (Rock 1987; Jain and Kini 2000; Khurshed 2000, etc.). It is also noted by Harper (2000) that there have been attempts made by known environmental and social groups to invest in companies in order to become shareholders and purposely raise their demands on the legitimacy of business activities and thus to change business principles and policies. Notably, such moves gradually gain momentum. Interestingly, not only are the financial community and social agents keen on pursuing sustainability movement, but regulatory bodies have also begun to become active.

Furthermore, in a world characterized by stiff competition, enhanced environmental awareness, increasing people's participation in decision making, and better informed and better organized consumers, reputation or corporate identity has become a much valued asset in the corporate world (Tomei 1998; Melewar and Harrold 2000; Balmer 2001). An organization's identity, according to Van Riel and Balmer (1997), is expressed to its stakeholders through its behavior, communication, and symbolism regarding what it stands for and believes in, and what it actually does. Obviously, misbehavior damages the reputation. It is not only the public reputation of a company that suffers in the occurrence of such organizational misbehavior, but damage is also done to institutional morale and thus can cause the disintegration of valuable employees (Albinger and Freeman 2000). Hence, the lack of corporate identity can bring adverse consequences, as it sends inconsistent and unclear messages to stakeholders that in turn contribute to the loss of competitive advantage in many forms and fronts. It also implies that sustainable businesses prosper through reputation management (Melewar and Jenkins 2000; Arkin 2001), in addition to relationship management that can trigger further benefits, for instance, work force motivation, attraction of talent, particularly at the highly skilled and highly educated end, etc.

3 Clearing the Path and Riding the Wave

Feeling the pulse, many organizations have begun to develop sustainability policies, but, say Bradely and Hartog (2000), long-term vision is still less well defined. This can perhaps be attributable to the fact that the topic of sustainable business might have been seen to be relatively more complex than it first appears. This can be a principal reason for many arguments that sustainability is still limited to the *political* level of executives with no serious actions or real commitments. This skepticism has further been supported by various incidents that have taken place recently in many industrial sectors globally. Those events and current public opinion demonstrate that the concept of sustainable business is still in its infancy and needs to be addressed more thoroughly and consistently to make it a full-blown business concept. Many multinational corporations want to accept this challenge but are still exploring how to integrate the concept into their corporate strategies (Hargis 2000; Browne 1998), under various complex conditions.

As the concept of sustainability gains acceptance, it is clear that businesses are increasingly challenged to find their place in this movement. In fact, in the view of some, it is not something absolutely new but rather a continuation and improvement of existing practices (Browne 1998; Abbott et al. 2001). For instance, it is claimed that many businesses already play a role in sustainability issues through energy supply, wealth creation, employment and development, transfer of technology and skills, undertaking transformation to renewable energy, etc. (e.g., Armstrong 1994; Bradely and Hartog 2000). Yet, although economics and for the most part environmental issues are generally well addressed, consideration of social issues lags behind and, hence, still a lot more needs to be done with regard to mitigating or preventing adverse impacts (Tomei 1998; Bradely and Hartog 1998; Abbott et al. 2001). Obviously, issues are still complex and not all the aspects are very well defined, let alone having a clear resolution. Techniques such as *Virtue Matrix* (Martin 2002) can be useful under such conditions at least to identify forces that shape the current movement in order to adapt.

Existing diverse views and opinions about sustainability issues are attributable, according to Bradely and Hartog (1998), Wolff et al. (2000), etc., to twofold aspect:

- firstly, much of the discussion has often remained theoretical, and
- secondly, there are no structured and consistent mechanisms to guide companies systematically to take into account sustainability issues when undertaking new activities with existing assets.

According to Wood and Jones (1995), current bottlenecks also include failure to trace the web of social policies, methodological shortcomings, stakeholder mis-matching (i.e., simply focusing on major shareholders alone), inadequate and unclear management frameworks, etc.

…The prevailing ambiguity, elusiveness, and skepticism on the subject have to be addressed directly, if any rapid progress is to be seen. Professional bodies and trade organizations have an important role in this context. For instance, the United Kingdom Offshore Operators Association (2001) offered a framework for the oil and gas sector through its publication entitled *Striking a Balance: The UK offshore oil and gas industry strategy for its contribution to sustainable development 2001*. The framework has been built on the UK government's definition of sustainable development; it mainly covers aspects related to *economic, social* and *environmental* sustainability, *stewardship*, and *delivery*. Similar outlines have also been drawn by Bradely and Hartog (1998), Wolff et al. (2000), etc., in an effort to promote the concept across major industrial sectors. However, much more work is still needed in both theoretical and practical terms to develop detailed reference cases and standards to boost the current state and pace of developments.

4 The Business Case

The way in which sustainability makes good business sense by linking business principles and results has been illustrated by many organizations in diverse ways. For instance, in the oil and gas sector, Shell (2001) and Statoil (2002) insist that by embedding sustainable management criteria for business decisions and actions, organizations can maximize performance through various key business levers (also see Adams 2001):

- *Reducing costs*: in the short term by becoming more eco-efficient (doing more with less) and in the long term by working with others to ensure that nothing is wasted and new cost-efficient technologies are applied. This involves doing more with less energy and material, adopting cleaner technologies, reducing exposure to current and future costs of emissions such as CO_2, decommissioning and waste disposal, turning waste into saleable products, etc.
- *Creating options*: anticipating new markets driven by people who want a more sustainable world, and evolving business portfolios and supply chain relationships to match. Focusing on managing existing assets in the short term and evolving the business portfolio longer term and thus achieving recognition from financial institutions for success in portfolio management.
- *Reducing risk*: companies can gain new insights into societies and increase their understanding of host countries through social engagements, which make companies better equipped to deal with 'above-ground risks' (political and commercial), other than technical risk. This underlines managing risk better by understanding what stakeholders perceive as adequate responsible behavior,

meeting the expectations of those who are being affected, achieving recognition from financial institutions and investors, and gaining customer preference for doing so.

- *Attracting investments*: experience has proven that it is of considerable economic importance to ensure that a company has a good reputation in markets where consumers are increasingly socially aware. A growing number of investors now set social responsibility criteria for the use of their funds.
- *Reputational dividends*: companies that act in accordance with principles of good corporate citizenship may reap the rewards of good image and reputation that can be linked to long-term benefits of various forms.
- *Gaining customers*: enhancing the brand by providing services and products built on sustainability thinking to create customer loyalty and market share.
- *Capturing talent*: selectivity can be a feature of the employment market: A high profile in the area of social responsibility will help to attract valuable competence. Sustainable business is considered an important factor in people's decisions to join and stay. The potential alignment between the personal values of staff and corporate values acts as a powerful motivator.
- *Influencing product and service innovation*: through differentiation of existing products and by providing more services to customers that reflect changes in lifestyles and values. Attracting more loyal customers and enhancing the brand—providing products and services built on sustainability thinking to create customer loyalty and market share.
- *Creating leadership, gaining intelligence, improved community relations, etc.*

The demand, which is growing in popularity for more socially responsible performance by various business sectors, involves reconciling their legitimate search for profits with a respect for the rights and demands of stakeholders. This requires a reorientation of the business paradigm based on a rigorous and responsible assessment of trade-offs between temporary economic gains and the longer-term payback to stakeholders (Tomei 1998). It is not incompatible, even with respect to shareholder value, notes Martin (2002), to be on the right side of the law and the creation of goodwill.

5 Communicating with Stakeholders

In conjunction with a change of policies and principles, businesses also need effective strategies for communicating with stakeholders, particularly their shareholders, so that they comply with demanding policies by transforming them into actions. In fact, companies have been devising new techniques for measuring and reporting their performance in line with business transformations. These include both financial and non-financial performance, and, according to Gilmour and Caplan (2001), particularly those areas that demonstrate the level of reputation, which can underpin shareholder value. PricewaterhouseCoopers (1999), for instance, recommends that good reporting practice should aim at explaining the overall business condition, financial position, and corporate citizenship, and it thus insists on adopting a more comprehensive reporting model termed a *Value Reporting Technique*. In the O&G industry, for example in 1996, a project consortium, comprising *Statoil, BP, Conoco*, and *Shell*, developed a benchmarking portal to review how companies in the oil business deal with the issue of sustainable development (Wolff et al. 2000). This portal primarily constituted five target areas, namely *ethics/corporate core values, community capacity building, stakeholder relations, environmental management*, and *economics*. Bradely and Hartog (1998) discuss a similar protocol, termed the *Sustainable Development Company Evaluation Tool*, for reviewing a company's position in terms of its policies and practices. Such initiatives are with a part of a revised business performance reporting and verification process that equally contains information related to economic, environmental and social performance (Wolff et al. 2000; Bradely and Hartog 2000; Abbott et al. 2001). Notably, a newly formed institution called the *Global Reporting Initiative* (GRI) (GRI 2003) has introduced some guidelines for such sustainability reporting for more than 30 global industrial sectors. The *Global Reporting Initiative* (GRI) is a multi-stakeholder process and an independent institution, whose mission is to develop and disseminate globally applicable *Sustainability Reporting Guidelines*. These guidelines are for voluntary use by organizations to report on the economic, environmental, and social dimensions of their activities, products, and services. The GRI incorporates the active participation of representatives from business, accountancy, investment, environmental, human rights, research, and labor organizations from around the world. Started in 1997 by the *Coalition for Environmentally Responsible Economies* (CERES), the GRI became independent in 2002 and is an official collaborating center of the *United Nations Environment Program* (UNEP), working in cooperation with the UN's *Global Compact* initiative.

Notably, moving with the flow, organizations around the world have begun to explore and identify better and more sustainable ways of doing business and reporting their performance to meet what is termed by Elkington (1997) as the *triple-bottomline*. Such efforts are worthy as they allow many sectors and organizations to change the public perception of their activities in order to create various opportunities and reducing risks (Browne 1998). It certainly caters to the needs of investors, particularly in their decision-making process, since the higher the uncertainties and the more volatile the sector is, the greater the information and knowledge requirements for secure investments will be.

Effective reporting can also be viewed as a means of actively engaging with stakeholders by disclosing adequate corporate information. The absence of such information can trigger various reactions from stakeholders, which can perhaps be too serious to ignore. However, as noted by Bradely and Hartog (2000) and Swift et al. (2001), the integration of strategic components for a proper reporting and verification process is still lacking. This is not an issue to be ignored, as there is evidence that each stakeholder group judges a firm's relative merits by interpreting that information and makes comparisons of competing reputation signals when making decisions (Fombrun and Shanely 1990). In that respect, a characteristic of such reporting, if an organization chooses to disclose information in respect of openness and transparency, is credibility—particularly after various recent incidents such as financial scandals.

6 Bridging the Gap

Sustainable business can be described as an evolutionary process (Abbott et al. 2001) that is often seen as the next step-change advancement in an evolving process of business improvements. It can also be regarded as an outcome of a learning process (Bradely and Hartog 1998) that requires new ways of thinking throughout all levels of business operations. Abbott et al. (2001) see it as a purposeful journey toward a destination, where leading organizations well understand that their survival depends on it. In essence, sustainable business is a multidisciplinary endeavor (Browne 1998) that pursues coordinated environmental, economic, and social objectives (Waible et al. 1996). The transition to reaping the benefits of this emerging move toward sustainability should be clear and gradual, yet consistent and systematic. There are various key factors that play a role here, for instance: leadership and commitment, staff engagement, stepwise approaches in rolling-out the sustainability practice in individual organizational settings to make it truly result-driven (see Tomei 1998; Bradely and Hartog 1998; Russo and Fouts 1997; Dutton and Duncan 1987; Somers 2001; etc.).

Sustainable business speaks the language of engagement, integration, and balance (Tomei 1998; Wolff et al. 2000; Agbon 2000; Bradely and Hartog 2000; Abbott et al. 2001). It integrates the economic, social, and environmental aspects of activities and balances the short- and long-term needs of various stakeholders, making adequate allowances for their direct engagement. Obviously, sustainability goes beyond abstract principles, ethical concerns, fears of ecological disaster, etc., to include new products and processes, creating markets, and the avoidance of costs associated with waste, energy, pollution, poor public image, and liabilities (Smith 1998). Making a clear transition to a sustainable path requires new and innovative approaches to addressing new and different objectives, and hence, it can be a long-term complex task, for instance, involving technological innovation, new business models, specifications, etc.

The notion of being consistent and systematic to achieve the fullest benefits implies the formulation of a clear path to achieve success through a change of course that also importantly involves *discipline, integrity,* and *culture* beyond the *commitment* expressed.

- *Integrity*—assurance of consistency in performance through policies, procedures, plans, etc., so that each party is aware of their own roles and responsibilities, what are their obligations, what they are accountable for, and how individual or team performance in turn affects business results.

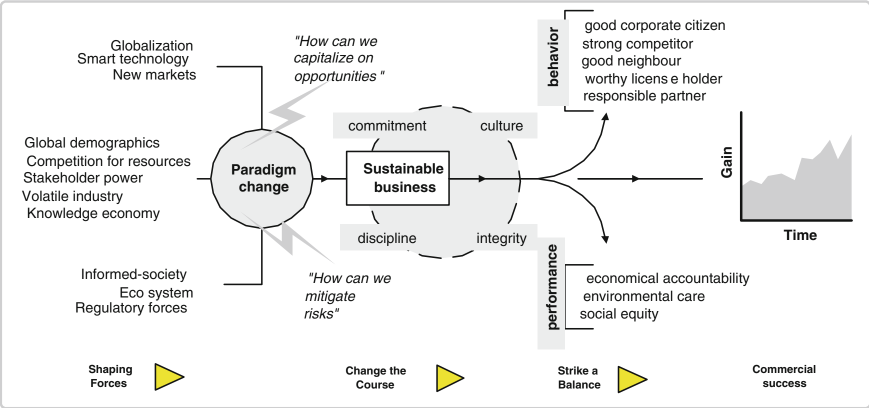

Fig. 1 Paving the way for a change of course to strike a balance between commercial success and the realization of sustainable business objectives

- *Discipline*—the assurance that policies, procedures, and plans are adequately and seriously being referred to and followed in decisions and actions across all portfolios.
- *Culture*—assurance of internal receptiveness, and the sustenance of performance through cultivation of pride of achievements, promotion of ownership, rewards for accomplishments, etc.

The current sustainable business performance path that organizations have taken in response to changing business demographics obviously presents a novel business model for commercial success that takes account of *economic, institutional* (statutory and regulatory), and *socially legitimate* (moral and ethical) aspects of complex business performance in the current dynamic and uncertain context (Fig. 1).

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Sustainable Manufacturing: Challenges, Approaches and a Roadmap

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Abstract Manufacturing is an important pillar of the society providing goods and services of primary importance for supporting the quality of human life. One of the most pressing challenges facing Europe and the world is the need for a transition to resource-efficient economy. Sustainability, in a manufacturing context, means enabling a diverse pool of industrial participants to pursue economic growth without undermining social and environmental issues of workforce management, building community relations, use of natural resources, carbon dioxide emissions, waste management and product and services responsibility. This chapter discusses on the relevance of sustainability from manufacturing perspective, sustainable manufacturing definition, strategies, impacts and approaches and describes a roadmap for sustainable manufacturing.

1 Introduction

Manufacturing is an important pillar of the society as 'it provides goods and services of primary importance for supporting the quality of human life' (Garetti and Taisch 2012). It is a complex and material and labour intensive sector influenced by the economic,

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political, social and technical developments with significant contribution to the world economy. In fact, manufacturing contribution to GDP in 2013[1] ranged from 12.4 % in the USA, 15 % as an average in EU countries and 22 % in East Asia and Pacific countries. Skinner (1969), recognising the need for a definition of manufacturing that reflected the proper concept, argued that 'manufacturing is generally perceived in the wrong way at the top, managed in the wrong way at the plant level and taught in the wrong way in the business school'. Miltenburg (2005) defines manufacturing as 'large numbers of employees—skilled and unskilled, line and staff, flexible and inflexible—work in a network of domestic and foreign facilities, formal and informal systems, good and bad practices, and old and new cultures coexist'.

Manufacturing is not only treated as a process but also referred to as a system (Robinson 1998). It includes an amalgamation of various aspects—production systems[2] (Miltenburg 2005), factory roles[3] (Ferdows 1997), manufacturing networks (Shi and Gregory 1998) and the manufacturing infrastructure and structure decision areas[4] (Hayes and Wheelwright 1984). Gregory (2005) has provided an integrative perspective of manufacturing—'manufacturing is a cycle that starts with understanding markets, product design, production, distribution and ends with manufacturing-related services within an economic and social context'. As such, the perception of manufacturing, initially, was on production activities. However, this has changed and the current focus of interest on the study of manufacturing has evolved to include a myriad of stages and activities from processing of raw materials to the production and delivery of a new product and finally to the reuse, recycling or disposal of the product, encompassing the whole product life. This perspective is adopted in recent publications, such as Garetti and Taisch (2012) who state that 'manufacturing is much more than production', integrating 'industrial activities from the customer to the factory and back to the customer, thus including all the different kinds of services that are connected to the manufacturing chain'. Extending manufacturing scope towards responsibility, overall product life cycle has risen an enormous interest in new service offerings. A range of service-oriented concepts can be found to address more customer-oriented approaches, such as integrated solutions (Tan et al. 2010). The following sections will elaborate on the relevance of sustainability from manufacturing perspective, sustainable manufacturing definition, strategies, impacts and approaches and will describe a roadmap for sustainable manufacturing.

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[1]World Bank Open Data, related to 2013 GDP (Gross Domestic Product), accessible from: http://data.worldbank.org/indicator/NV.IND.MANF.ZS.

[2]Job shop, batch flow, operator-paced line flow, equipment-paced line flow, continuous flow, just in time, flexible manufacturing system.

[3]Offshore, source, lead, outpost, contributor and server.

[4]Infrastructure decision areas: resource allocation and capital budgeting systems, human resource systems, work planning and control systems, quality systems, measurement and reward systems, product and process development systems, organisation. Structural decision areas: capacity, sourcing and vertical integration, facilities, information and process technology.

2 Relevance of Sustainability from Manufacturing Perspective

Manufacturing includes industrial activities from the customer to the factory and back to the customer, either in the form of a business-to-business (B2B) or business-to-consumer (B2C) relationship. Likewise, different industrial services are also an important constituting part of the manufacturing activities. The constant evolution of manufacturing networks—coordination and cooperation between the capabilities and configurations—become vital for growth. External (macroeconomic stability, trade policies) and internal factors (process innovations, cost benefits, competition, corporate culture, organisational structure) have both led companies to change production systems and locations in order to maximise benefits (CEN 2014). Globalisation—expansion of manufacturing operations to developing economies and the ever-changing business environment, which affects the wider society and environment, highlights the requirement for manufacturers to look for new approaches to manage sustainability. As such, complexities of interactions between various stakeholders along a product life emerge, which raises a myriad number of challenges for sustainability. The challenges include social and environmental concerns such as labour practices, community involvement, waste generation, product end of life, packaging, climate change and partnerships, further propagated by demand, global competition, consumer preferences and behaviour.

In the quest for new approaches to manage sustainability impacts effectively in manufacturing—from sourcing and production to distribution, product logistical support and end of life, many methodologies to assess and plan manufacturing activities based on the product life cycle perspectives have been developed. Sustainability assessment methodologies in literature are currently numerous. Some of them propose theoretical approaches, others specific industrial cases. The majority of them are focused on a specific sustainability dimension (economic, environmental or social), within which only few impact categories are addressed. It is rare that methodologies reach complete integration over the triple bottom line, even if many authors express its desirability (Kloepffer 2008; Rebitzer and Hunkeler 2003; Hunkeler and Rebitzer 2005). It is worth highlighting that economic, environmental and social assessment of the product life are not yet mature at the same level. For example, economic sustainability is assessed from the conception of a business, where financial assessments are known for their importance in decision-making in companies. The life cycle perspective is claimed to avoid selecting an alternative with lower initial costs but higher operations and maintenance costs; indeed, usage costs may be equal to many times the initial purchase or investment costs (Woodward 1997; Markeset and Kumar 2003). The most common environmental assessment technique is the life cycle assessment (LCA), described in the International ISO 14040 standard (ISO 2006). Social sustainability is still poorly considered, as social issues are difficult to quantify in relation to flows related to the product life. Moreover, it is complex to obtain and manage the required information type: It is tightly linked to company's conduct and its impacts; thus, it is very highly context specific (Dreyer et al. 2005; Jørgensen et al. 2007).

Many research projects and industrial activities consider products, processes and services along their complete life cycle. The role of information sharing along the life cycle has become an important issue for achieving sustainability (Terzi et al. 2010). In particular, information sharing is a base for various activities such as designing products for sustainability, sharing knowledge between customers and suppliers (two main among stakeholders) and optimising operations by closing the information loops with the involvement of product-service users. Manufacturing characteristics have altered or advanced according to the changes in the global business environment over the last decades, also building on the challenges arising from the sustainability perspective.

The relevance of manufacturing industry has been outlined by the European vision for the future 'Competitive and Sustainable Manufacturing': it promotes the transformation of the European manufacturing industry into a high added value and knowledge-based industry, which is competitive in the globalised world (European Commission 2010b). Manufacturing industry is crucial for the European economy. However, the ongoing economic crisis has hit the industry severely both in terms of industrial output and number of jobs. In several industrial branches, a general problem is the overcapacity and low return on investment. Manufacturers' search for new markets, increased efficiency and low-cost production has led them increasingly to invest in non-EU countries leading to the development of global value chains (European Commission 2010a). One of the most pressing challenges facing Europe and the world is the need for a transition to resource-efficient economy. These trends reflect in the European vision for the future 'Competitive and Sustainable Manufacturing'. Accordingly, some of the challenges anticipated for the future to support the vision are as follows:

- A key factor in the development of the manufacturing systems will be the ability to achieve cost-efficiency, high performance and increased resilience to meet varying and segmented customer demands in dynamic and fluctuating markets (Foresight 2013);
- In terms of asset management, the key issues are dynamic and continual life cycle management, optimal capacity development and utilisation, higher overall equipment effectiveness, reliability and flexibility of physical assets, and lower maintenance cost (Komonen et al. 2012);
- There is also a need to develop strategies to help manufacturing industries to cope with the challenges of a low carbon economy (European Commission 2010b);
- The existing business models predominantly create, deliver and capture economic value for a few stakeholders such as customers and shareholders, with limited or no attention to environmental and social value. These business models are linear and externalise environmental and social impacts.

As summarised above, the relevance of sustainability in manufacturing is evident. Moreover, the focus of various research supported by the European Commission has encouraged thinking of new perspectives in manufacturing associated with sustainability challenges and, more recently, developing correspondent approaches, systems and tools. In relation to the new perspectives, it is worth mentioning research initiatives such as the *IMS international project IMS 2020: supporting Global Research from IMS 2020 vision*, which was in charge of preparing a roadmap for future manufacturing research, and the *Factory of the Future Strategic Multi-annual Roadmap* (European Commission 2010b), prepared by the Industrial Advisory Group for the Factories of the Future Public-Private Partnership.

3 Sustainable Manufacturing: Definitions, Strategies, Impacts and Approaches

3.1 Definitions and Current Strategies Towards Sustainability

The National Council for Advanced Manufacturing (NACFAM 2015) has defined sustainable manufacturing as 'the creation of manufactured products that use processes that are non-polluting, conserve energy and natural resources and are economically sound and safe for employees, communities and consumers'. Some definitions proposed in academic literature include the following:

- Hutchins and Sutherland (2008), define sustainable manufacturing as 'the design and operation of industrial systems to ensure that the use of natural resources does not lead to reduce the life quality either due to losses in future economic opportunities or due to adverse impacts on social conditions, human health and the environment'
- Despeisse et al. (2012) recognise sustainable manufacturing as 'a new paradigm for developing socially and environmentally sound techniques to transform materials into economically valuable goods'
- Garetti and Taisch (2012) state that sustainable manufacturing is 'the ability to smartly use natural resources for manufacturing, by creating products and solutions that, thanks to new technology, regulatory measures and coherent social behaviours, are able to satisfy economic, environmental and social objectives, thus preserving the environment, while continuing to improve the quality of human life'.

These are few examples that underline the emergence of economy, society, environment and technology as leading factors in order to orienteer manufacturing towards contributing to sustainability. As such, sustainability, in a manufacturing context, means enabling an eclectic pool of industrial participants (primary, public and secondary stakeholders) to pursue economic growth without undermining social and environmental issues of workforce management, building community relations, use of natural resources, carbon dioxide emissions, waste management and product and services responsibility. Industrial sustainability, for a long time, has been entrenched solely in economic sustainability with limited concern over social and environmental issues and impact on the wider society. However, undermining social and environmental issues is no longer acceptable to supporting industrial growth (Ashford et al. 2012). This process towards extending the concept of sustainability is ongoing (Valkokari et al. 2014).

Based on the three pillars of sustainability—environmental, social and economic, Jovane et al. (2008) have defined the following key challenges that sustainable manufacturing needs to respond to:

- Economic challenges, by creating products effectively and efficiently and creating new services that ensure development and competitiveness through time;
- Environmental challenges, by promoting minimal use of natural resources (in particular, non-renewable energy) and managing them in the best possible way while reducing environmental impact;
- Societal challenges, by promoting social development and improved quality of life through renewed quality of wealth and jobs.

Different strategies have been proposed to deal with these challenges, either focusing on one of the concrete aspects of them or addressing many of them from a more holistic perspective. An example of different strategies that can be applied by practitioners regarding the effective use of materials are those studied by Rashid et al. (2008) which are waste minimisation, material efficiency, resource efficiency and eco-efficiency. From a systemic perspective, Seliger et al. (2008) propose three strategies that manufacturing companies could pursue to contribute to sustainable manufacturing:

- The implementation of innovative technologies, which are used for resource-saving applications;
- The improvement of use intensity of products, by increasing the utilisation ratio of a product and its components through either service-oriented business models or distributed use of products and components;
- The extension of product life span, which can be achieved by expanding the use phase or by the realisation of multiple use phases.

The transition towards sustainable manufacturing will require significant shifts in the design, manufacture and use of products and services. Initiatives till date around eco-efficiency, eco-innovation, waste management, social responsibility are helpful but incremental and limited in their ability to drive system-wide changes. As suggested by Ijomah et al. (2007), ‘companies must design products for longevity and ease of recovery at end of life and must consider the business potential of processing used products to harness the residual value in their components’. Garetti and Taisch (2012) recommended ‘new strategies and solutions to obtain a better overall performance of high-tech engineering and manufacturing assets’. This would then enable longer equipment life cycles and higher performances in respect to resource and energy consumption, product quality and equipment availability, achieved through effective and efficient maintenance.

The transition is progressively induced by the consumer influence. Concern over social and environmental issues has resulted in rising consumer pressure for responsible corporate behaviour. Fréry (2006) writes about how scandals, like Enron and WorldCom, have highlighted the need for responsible corporate behaviour to prove that complete focus on short-term financial results can lead the company towards jeopardy and total closure. However, complete focus on best value to consumers and minimal consideration of financial results can also lead to problems for the long-term survival of the company. Hence, the author concludes that for 'sound strategy', both ends of the 'spectrum–shareholder value and customer satisfaction' need consideration (Fréry 2006).

Overall, the concept of sustainability recognises the linkages between social, economic and environmental issues. Therefore, in a company, the corporate strategy, as well as the manufacturing strategy, should realise how policies and decisions need to incorporate a broader view that encompasses environmental and social issues for longer-term benefits. As a report on global manufacturing states, 'a more productive and reliable approach involves a framework for decision-making that takes into account the many possible scenarios in an uncertain future' (Deloitte Research 2007). Although the report was towards building on strategy and scenario planning, its implication to the sustainability approach is the idea of incorporating the various factors towards a more united approach in dealing with uncertainty of today's business environment.

3.2 Current Impacts of Manufacturing Industry from a Sustainability Perspective

Industry is estimated to be responsible for some 30 % of the CO_2 emissions on the planet, is a major consumer itself of primary resources and non-renewables, and is the primary driver of end-user consumption of material goods (Evans et al. 2009). The impact on sustainability is also demonstrated by the relevance of energy consumption in manufacturing, primarily due to electrical energy and oil. The consumption of energy and other resources often represents a major part of the cost of manufactured products. It has been argued that energy and materials represent the largest costs for manufacturing companies at 45–55 % of total expenditure. Thus, energy and materials are the most critical cost factors and the competitiveness will be to a great extent determined by its capability to use resources as efficiently as possible (Greenovate 2012). Manufacturing has also a strong impact on water consumption. Industrial use of water accounts for 19 % of the global water extraction with the demand of water from manufacturing estimated to rise 400 % by 2050 (Royal Society 2012; OECD 2012). Besides a great impact on energy and resources consumption, the manufacturing sector is responsible for 38 % of total direct and indirect CO_2 emissions and emissions to the environment, as reported by the International Energy Agency (IEA 2008).

Industry also develops and promotes demand for products that through their use engender significant additional CO_2 emissions and other forms of subsequent pollution and waste. For example, the annual consumption in UK was around 13.2 million tonnes of paper and board products in 2008, 5 million tonnes of plastics are estimated to be annually used and 1.54 million tonnes of electronic and electrical equipment bought (WRAP 2011). This offers an overview of the impact of manufactured products on the environment at the end of their life as mostly these products do not get recovered, recycled yet.

Furthermore, the magnitude of the industrial sector, its global nature, use of natural resources for production, its role in technological innovation, its driving influence in most societies and its primary position in a consumer-based culture makes it central in impacting sustainability. Influencing positions of corporations becomes an important factor, with respect to both environmental and social contexts. Many corporations now wield considerably more influence than most sovereign states. Continuing business as usual, this power and influence could prove catastrophic for environmental and social sustainability.

Fulfilment of ambitious emission goals, especially the CO_2 emission targets, requires awareness and conscious decisions at all levels of the society. However, energy and resource efficient operation model should not be a burden to the European industry but to increase its competitiveness in the global market. Strengthening the competitiveness of the European products and companies via improved environmental profile requires measures that enhance use of environmental alternatives with lower CO_2 footprint to improve the energy efficiency without negative impact on industrial production and job opportunities in Europe.

While the EU has shown that progress on resource efficiency is possible and sustainability has gained importance on the agendas of industrial decision-makers, the rate of improvement in resource efficiency has been between 1 and 2 % a year, which is below the rate of economic growth (European Commission 2011). A radical shift is required, where manufacturing industry is considered pivotal in pursuing sustainable consumption of energy and natural resources and production solutions for energy and resource efficiency (Krantz et al. 2011).

3.3 Approaches to Integrate Sustainability in Manufacturing

3.3.1 Sustainability in Manufacturing Companies

Understanding of the term ‘sustainability’ still varies significantly between firms. Some consider mere compliance with environmental legislation to be sustainability; others see waste and cost reduction, or reduction of carbon emissions as sustainability, while others view workplace and employee rights or community engagement as sustainability (Bonini et al. 2010). The identification of energy, materials, waste and regulations to comply with allows manufacturing practitioners to establish their baselines and to identify the different impacts of their manufacturing activities. Willard (2005) proposes a 'corporate sustainability continuum', through which firms' progress on the path towards sustainability (Fig. 1).

Companies can go along the path towards sustainability by taking also proactive actions. In this regard, the application of new technologies can offer support to initiatives addressing sustainability challenges, for example for resource-efficiency applications (Seliger et al. 2008). Evans et al. (2009) discuss the potential additional benefits of applying new thinking of existing practices and knowledge considering a whole system perspective to achieve energy and resource efficiency as a first priority for manufacturing companies. Garetti and Taisch (2012) discuss another complementary vision that considers technological development as a part but not enough for a comprehensive view of sustainable manufacturing. A final perspective is related to education as 'the prerequisite for consumer and people in general to correctly address the sustainability objectives through appropriate lifestyles and the appropriate use of products and technology' (Garetti and Taisch 2012).

In summary, a mutual interaction can then be envisioned between manufacturing technologies and the economic pillar (i.e. technologies supporting the development and offering of new customer-centred solutions), the social pillar (i.e. technologies supporting changes in lifestyles/living models) and the environmental pillar (i.e. technologies affecting—positively or negatively—the use of natural resources).

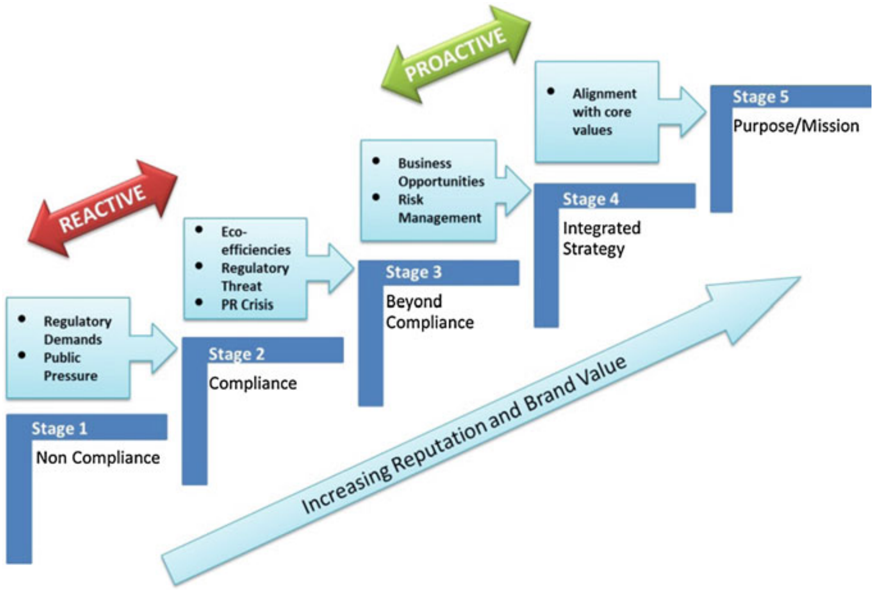

Fig. 1 Stages in corporate sustainability continuum (adapted from Willard 2005)

The 'corporate sustainability continuum' and the presence of educated/skilful people within the business ecosystem are some of the relevant means in the industrial context to understand, manage and monitor manufacturing technologies for sustainable purposes, thus facilitating the effective integration of sustainability in a manufacturing company.

3.3.2 Sustainability in Manufacturing Networks

In traditional manufacturing network operations of suppliers, lead producers (such as OEMs) and customers are seen as independent sequential tasks, which form a value chain. Since the 1990s, however, this pattern has been changing and the theoretical discussion has emphasised the transfer from value chains to value networks (Normann and Ramirez 1993; Peppard and Rylander 2006). In manufacturing industries, a value network consists of organisations cooperating with each other to benefit all network members. Lead producer and its suppliers and customers form a typical value network. Value system consists of the suppliers' value networks (who provide input), core company's value network (that produces products), the distributers' and retailer's value networks (who distribute products to customers) and the customers' value networks (who use the products in their own activities) (Miltenburg 2005). Thus, the whole system view will encompass groupings of different interconnected value networks.

At the network level, Van Bommel (2011) presented a framework for the analysis of the implementation of sustainability-oriented strategies considering network dynamics. He identified three types of strategies that an organisation within the network could follow:

- Resign strategy, which does not start any implementation activity related to sustainability;
- Defensive strategy, which includes supply chain management for risk and performance;
- Offensive strategy, which regards supply chain management for sustainable products.

These strategies are very ambivalent in practice and could actually be applied separately to different products within the same network. From the author's perspective, implementing sustainability can be seen as a whole system innovation with two key concepts: innovation pressure and innovation power. The innovation pressure exists from the stakeholders of the system and is closely related to the specific sector, product, service and its supply network. The innovation power is closely related to the strategy and activities decided to carry out by the organisation.

4 Sustainable Manufacturing Roadmap

The SustainValue project defined a roadmap for sustainable manufacturing industry in Europe. Literature on business models and value networks in the manufacturing industry defined the research background. An expert workshop provided the data for the roadmap analysis, which then went through several iterations by the project core group. Valkokari et al. (2014) and Kortelainen et al. (2015) present and discuss the roadmap in depth. The following paragraphs provide a short summary of the main findings.

Roadmaps are strategic tools for creating deeper understanding and setting agendas for development and change. Visionary socio-technical roadmaps are visualisations of knowledge based on expert assessment. They combine economic, societal and technological issues with explicitly stated visions of the future. The roadmap process is planned to identify elements and issues of development that have strong potential for producing the outcomes that the vision presents. Roadmaps are not intended to forecast the future in a deterministic way but they are based on the assumption that future development is likely to include some elements that are presented in these roadmaps (Ahlqvist et al. 2007; Ahola et al. 2010).

The visionary roadmap process guided the work on the SustainValue project that dealt with broad concepts such as sustainability, value and networks. The chosen time periods were short, middle (5 years) and long term (10 years). The future development was assessed from five perspectives, namely stakeholders, business ecosystem, success criteria, benefits/value and catalysts/obstacles. The roadmap process starts by defining a vision which serves as a target against which the current state is compared and the needed changes discussed. The vision for sustainability within the manufacturing industry was stated as new forms of business models and value networks, which together enable knowledge-based transformation of the manufacturing industry and improve the three dimensions of sustainable value (economic, environmental and social) (Valkokari et al. 2012).

The road mapping process started from definition of the current state of sustainability within the European manufacturing industry, followed by discussion and road mapping of the changes that are required for a transition towards a sustainable manufacturing industry. The roadmap was split into three sub-roadmaps (Valkokari et al. 2014):

- Empowerment of stakeholders in the European manufacturing industry.
- Increasing efficiency at network level.
- Creating new performance criteria, models and means of measuring success at actor level.

The key features of the roadmaps are summarised in Table 1.

Sustainability should be seen as a key criterion for decisions that will create value today and in future. The three sub-roadmaps emphasise importance of wider adoption of system thinking. Many companies are taking some steps towards sustainable manufacturing, but seldom in a holistic manner. Every participant in the

Table 1 Key characters of the three sub-roadmaps (adapted from Valkokari et al. 2014)

Sub-roadmap	Key features
Empowerment of stakeholders in the European manufacturing industry	• Need for better awareness and changed behaviour in relation to sustainability issues such as limited resources, the three sustainability pillars and life cycle thinking • Standardisation and legislation that supports sustainable manufacturing • Improved ways to demonstrate the benefits for customers and companies of developing their actions, products, processes and services so as to be more sustainable
Increasing efficiency at network level	• Efficiency in production and manufacturing, as well as operational efficiency of products, systems and services, has to rise • New types of relationships and collaboration are needed between manufacturers and stakeholders • The focus of manufacturing has to move from products to new kinds of services and solutions • Effective ways to deal with the new sustainability requirements of product–service systems have to be implemented in product development processes
Creating new performance criteria, models and means of measuring success at actor level	• Updating of current business models • Making sustainability measurable • Measuring business success through consideration of all sustainability pillars

manufacturing network must have an understanding of the challenges and opportunities of sustainability. Currently, network level sustainability governance mechanisms are not well suited for managing sustainability. There is a need for collateral, horizontal relationships and a joint development process among stakeholders. Rethinking business models at network level is essential, and sustainability is one possible enabler of future competitive advantage within the manufacturing industry. An important key is collaboration between stakeholders for change. Development of common approaches and shared transparent KPIs for sustainability within manufacturing networks can enable collaboration among network partners and stakeholders for sustainability (Valkokari et al. 2014).

5 Conclusions

Manufacturing companies must take into consideration not just the economic goals but also the need to meet environmental and social goals in carrying out business, while recognising that economic, environmental and social impacts occur at all stages in the value network. This implies not only being able to manage internal activities and operations of the producing organisation but also getting the value network partners to collaborate on principles and performance standards that have positive and implicit or explicit influence on the sustainable products and services delivery performance. Sustainable value creation is the key contribution of companies to sustainability, i.e. to create long-term environmental, social and economic value. Developing attractive and common approaches for sustainable products and services can assist in enabling collaboration among partners and stakeholders.

The existing business models are often based on creating, delivering and capturing economic value for customers and shareholders, with limited or no attention to environmental and social value and to a broader range of stakeholders. These business models are linear and externalise environmental and social impacts. They cannot support the sustainable value creation that is required to meet the future needs of the planet and of increasingly discerning customers wanting features other than economic value or product ownership.

It is important to provide tools and methodologies for companies to fully embrace sustainability. It also is important to do this at the level of the network, as the impacts do not mainly occur inside one company. The emerging sustainability megatrend is becoming a central factor in companies' long-term competitiveness, and when doing this, it will affect their production networks. The business partners and stakeholders within these networks make planning, coordination and management a challenging task. The decision-making setting is difficult due to the decentralised nature of business decisions and operational activities. In this context, a major impact on the networked manufacturing environments could be achieved through holistic and integrated solutions for sustainability of complex value chains, rather than isolated and ad hoc solutions.

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Towards Sustainability Governance in Value Networks

Katri Valkokari and Padmakshi Rana

1 Introduction—Need for Network Governance

No organization is an island—all need relationships with other organizations to survive and grow. Furthermore, in the present networked environment the traditional focus on firms as discrete entities is increasingly inappropriate, and multiple values and conflicting interests must be considered at both *value network* and *business ecosystem* levels (Valkokari et al. 2012). In particular, sustainability as future-oriented business development task challenges companies to rethink their current business operations and network structures.

In the context of sustainability and performance management, three general levels of analysis can be distinguished: (i) micro-level, where system boundaries would equal firm boundaries, (ii) meso-level, where the system boundaries are represented by the boundaries of the value network consisting of several companies (including suppliers, their customers and service providers[1]) and (iii) global

[1]In the context of manufacturing industry, this supply–demand network is typically defined with the term supply (or value) chain. Originating from the automotive and aerospace industries, the aim of the linear manufacturing-based supply chains was to optimize the material and information flow and utilization of resources to satisfy the customer. Instead of "supply chain", the term **value network** is utilized in this chapter in order to emphasize that (i) supply systems are more complex than the term chain addresses, (ii) within them co-operation and collaboration should be interactive rather than sequential, (iii) both downstream (customer) and upstream (supply) operations should be considered and (iv) the role of the other actors than direct suppliers and customers should be considered.

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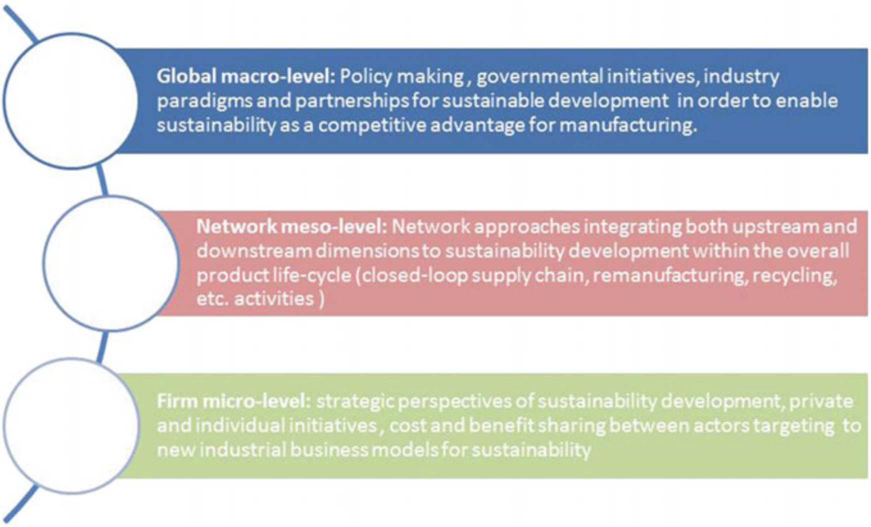

Fig. 1 The three levels of sustainability governance in manufacturing industry

macro-level, where system boundaries are more open, as through its life cycle the product enters and exits several global meso-level (and micro-level) systems, e.g. networks and intra-organizational operations focusing on R&D, production, distribution or services.

Figure 1 illustrates the different viewpoints at the three levels of analysis: global macro-level, value network meso-level and firm micro-level (modified from Liyanage et al. 2012; Valkokari et al. 2014). In this chapter, we will focus on the meso-level, e.g. *value network governance for sustainability*, although it must be noticed that the other two levels have an influence to the value network level. Network governance models that integrate both upstream (supply chain management) and downstream (customer relationship management) are required in order to develop, produce and distribute sustainable products and service in the context of manufacturing industry. Furthermore, the concept of value network highlights how value network generates economic value through complex dynamic exchanges between customers and suppliers. These networks engage in more than just transactions around goods, services and revenue, while the network actors share critical knowledge, resources and/or financial assets in order to co-create value.

All the meso-level value networks are circled with broader global business ecosystems, where in addition to direct suppliers and customers other loosely coupled stakeholders[2] are involved. One of the key benefits from the involvement of different stakeholders is their ability to support diversity, bringing insights from

[2]A stakeholder is any group or individual who is affecting or can be affected by the achievement of organization objectives.

different viewpoints and backgrounds. On the other hand, growing and nested regulatory landscape has already had impacts on industry and network level practices regarding sustainable development in several areas such as energy sourcing, resource efficiency, logistics and production processes.

Figure 2 represents the borders and main actors of both the value network and the business ecosystem. In the context of the manufacturing industry, value networks present well-defined demand—supply networks (e.g. a supply chain), and a business ecosystem can be defined as a broader value system in which all stakeholders act, co-produce and capture value from the co-operation. Thus, over the products' life cycle also the value networks have different value co-creation operations from research & development (R&D) to production and services. The key players of value network are the direct suppliers and customers of the focal company. But also the suppliers of a supplier and customers of the customers should be included, when considering the sustainability within the value network.

At the business ecosystem level, sustainability can be defined as the capacity of ecosystems to maintain necessary processes and functions and to retain biological diversity without impoverishment. On the other hand, at the value network level any form of economic development is sustainable if it does not violate or destroy the limits of our human condition either presently or in the future (Ueda et al. 2009).

The ability to develop business collaboratively in inter-organizational networks is essential for the future success of firms. In other words, firms are strategically engaging in networks of interconnected, interdependent actors, whose actions influence to their success. Networks of organizations can comprise many different types of inter-organizational relationships, such as common supply relationships, R&D partnerships and strategic alliances, service contracts, marketing relationships, joint ventures, outsourcing and offshoring partnerships, logistical partnerships,

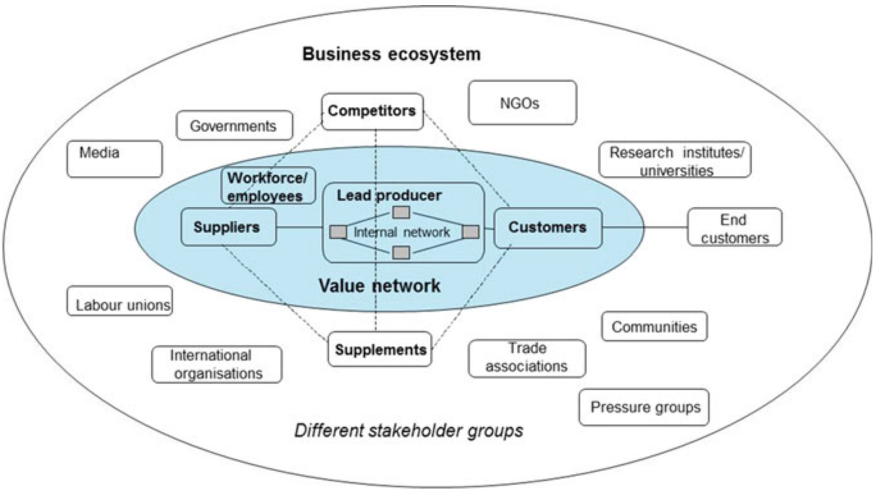

Fig. 2 Value network and business ecosystem in manufacturing

equity swap relations, and the like more. Academic discussion has typically focused on specific inter-organizational relationship form (for summary see for instance Parmigiani and Rivera-Santos 2011) and created a conceptual chaos regarding to collaboration models.[3] Thus, there is not "one size that fits all". The different collaboration models have their strengths and weaknesses and can be utilized for different purposes. Within network governance, companies should identify the most appropriate collaboration model, manage different structures simultaneously and also be ready to change from one network structure to another when the objectives are changing.

2 Network Structures in Global Manufacturing Industry

The global industrial systems are one of the major drivers in improving the quality of life of peoples around the world, although at same time manufacturing systems have a significant influence on the deterioration of the global environment. Commoditization[4] and servitization among other trends lead manufacturers to consider means to increase the value of their products to the likely users, whereas sustainability even broadens the consideration to levels of society and environment. The growing complexity and shorter life cycles of products also drive companies to collaborate in new ways. Now the success of a firm depends on its strategic collaboration with other organizations that have an influence on the creation and delivery of its services or products.

Thus, the global distribution of work within the manufacturing industry and the growing importance of service business alongside other structural changes in networks have challenged the traditional business models in Western countries, emphasizing value co-creation between all involved actors. Thus, "sustainable value" must be a synthetic value that is achievable through dynamic interaction among actors (both stakeholders and network members) that have various goals and values (Ueda et al. 2009). The collaboration model of global value network depends on several variables: the complexity of exchanges (product versus services), network design (structure, processes and members), knowledge base (tacit versus explicit knowledge) and the capabilities of network actors. Still, there is no single best way to organize global value chains and networks. In some product categories, where integral product architecture makes it difficult to break the value chain vertically integrated chain would be most competitive as several examples from consumer electronics address. On the other, Zara has succeeded to operate its rapid

[3]Researchers employ different definitions also to the term collaboration. Here, collaboration is defined as any joint, interactive activity, where two or more organisations are working together in order to create value to all involved actors.

[4]The word "commoditization" means transformation of differential goods or services into commodities.

product life cycles by its internal manufacturing subsidiary and effective distribution chain (Gereffi et al. 2005).

The companies cannot solve the complex sustainability challenges alone. The focal companies of value networks are now also asked to consider the sustainability performance of their entire supply chain to cope with new requirements and interests from customers and other stakeholders. The advantages of network coordination are considerable and, alongside the opportunity to address sustainability, they include enhanced learning, more efficient use of resources, increased capacity to plan for and address complex problems, greater competitiveness and better services for clients and customers. Furthermore, governance models based on collaboration have started to become evident, as they enhance social control pressuring participants into seeking multilateral benefits at network level instead of unilateral benefits at the firm level (Vurro et al. 2009).

3 Changes in Manufacturing Industry—Towards Value Networks

The concept of value networks represents a paradigm shift towards the co-creation of multiple sustainable values between network actors. The trend among customers, lead producers (OEMs) and suppliers seems to be to engage in forward transfer in their value networks. This means that customers, lead producers or OEMs outsource manufacturing (give up earlier value chain phases), and their suppliers try to increase services (add later value chain phases and give up some of the earlier phases). Although a focus on supply chains can be seen as a step towards sustainability (Ashby et al. 2012), they do typically consider business opportunities and development needs at different levels of value network. In other words, the sustainable supply chain management (SSCM) approaches target to remain at status-quo and do not explore new possibilities necessitating changes in network configuration or roles of network actors. Gereffi et al. (2005) stated how increasing capabilities in the supplier base have pushed the structure of global value chains towards relational and modular network models. Interdependency of operations and co-creation between the actors has been emphasized from several theoretical viewpoints (von Hippel 1988; Dyer 2000; Chesbrough 2003; von Hippel 2005).

Within the discussion related to the concept of value networks, researchers have begun to propose that supply chains are not as sequential as a traditional chain structure has suggested. Figure 3 illustrates the need for new kind of collaborative approach within value networks in the context of manufacturing industry. Still, in practice, co-operation of networks is mostly limited to bilateral collaboration, e.g. vertical relationships between a customer and a supplier, and the change towards network level decision-making and operations is in the wind. In reality, few companies (if any) have even the visibility over their entire value network, and thereby they focus on co-operation with the closest (often the 1-tier) suppliers and key customers.

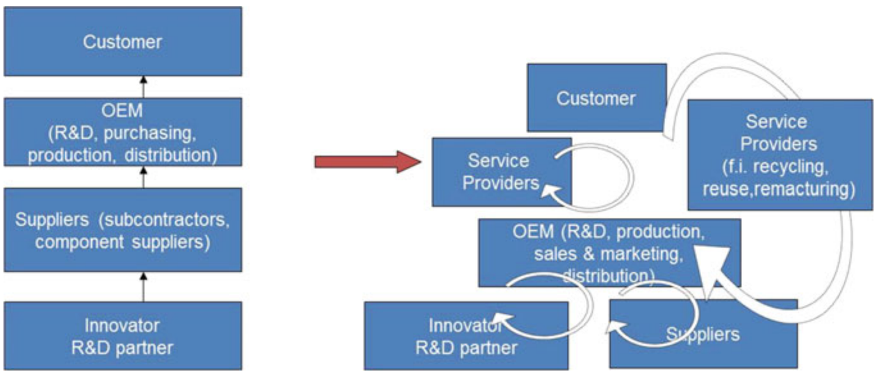

Fig. 3 Change towards value networks

As described in Fig. 3, suppliers are stepping up their participation in the development processes of their customers and different forms of joint development, inter-organizational innovation relationships and collaboration are emerging (von Hippel 1988; Dyer 2000; Chesbrough 2003). Gold et al. (2010) state that collaboration is even more essential when value network aims at ensuring simultaneously economic, environmental and social performance on a product's total life cycle basis. Hence, the network model and, thereby, the business logic of value network is still mainly defined by the lead actor and it affects in broad terms the firm-specific business models required of all the other value network actors. Anyhow, the network perspectives related to sustainability highlight the involvement all stakeholders (Boutilier 2009)—including other actors than the direct members of value network, e.g. considering the business ecosystem as a whole (see Fig. 2).

Since manufacturing activities are presently organized through networked processes, new models for network governance are needed in order to ensure sustainable development and performance. These models should enable clear identification of value network actors and stakeholders, who are influencing and can be influenced by the sustainability of the product during its life cycle.

> The network governance model defines "what to do", "how to do it", "who should do it" and "how it should be measured".

The network governance model addresses the rules, processes, metrics and organizational structures needed for effective planning, decision-making, steering and control. The main differences between the company and the network governance models are related to legal aspects, decision-making processes and control mechanisms. Companies are legal entities with their own goals and their decision-making is based on hierarchical structures (control governance) inside the company, whereas networks consist of independent actors, who have their own targets and decision-making models. Furthermore, network approach refers to inter-organizational collaboration practices that support the creation of multiple value propositions and considers trade-offs between these value propositions from the view of all stakeholders, which seems essential for the design and development of sustainable business model innovations. Thus, a business ecosystem view will support value network actors to rethink their current business models. Through broader considerations, such as value mapping approach (see Chaps. "Toolset for Sustainable Business Modelling", "Methods and Tools for Sustainable Development of Products and Services"), they are able to identify areas where there is no business case yet.

4 Network Governance Models in Manufacturing Industry

Networks are a hybrid model between hierarchies and markets and have characteristics from the both opposite dimensions. According to their structure, networks can be divided into hierarchical hub-spoke and multiplex model (Doz 2001). Within the hub-spoke model, the central actor, e.g. the lead producer or OEM, is responsible for the network governance. On the other hand, in the multiplex model the network governance takes place within and between the network actors. Provan et al. (2007) identify three distinct types of governance within networks: (i) shared governance, (ii) lead organization governed and (iii) network administrative organization (NAO) governed. Under NAO governance, all activities and decisions are coordinated through one organization specifically created to oversee the network. This kind of third-party acting as a link between actors is often called as an intermediator or a middleman. In the context of manufacturing industry, the intermediation means a typically link between manufacturer (or supplier) and customer—such as distributor or agent. Anyhow, network governance is rarely included in their tasks.

Figure 4 presents these three network governance models. Thus, the governance patterns are not static or strictly associated with certain structures. They depend on the details how interaction between network actors is managed, how technologies are applied to design, production, distribution or services and how joint actions are leaded within the value network itself (Gereffi et al. 2005). Furthermore, decentralized structures, where several sub-networks exist, may empower actors' participation more than centralized models with one organization leading the collaboration.

Governance structures are what bring actors into working together—the process, rules and norms by which the network enables individuals to influence to network's operations and decision-making. Governance mechanisms are divided into contractual-based and relational-based governance (Poppo and Zenger 2002). Contractual governance emphasizes the use of a formalized, legally binding agreement to govern the inter-firm relationship. Relational-based governance, by contrast, highlights the role of norms of solidarity, flexibility and information

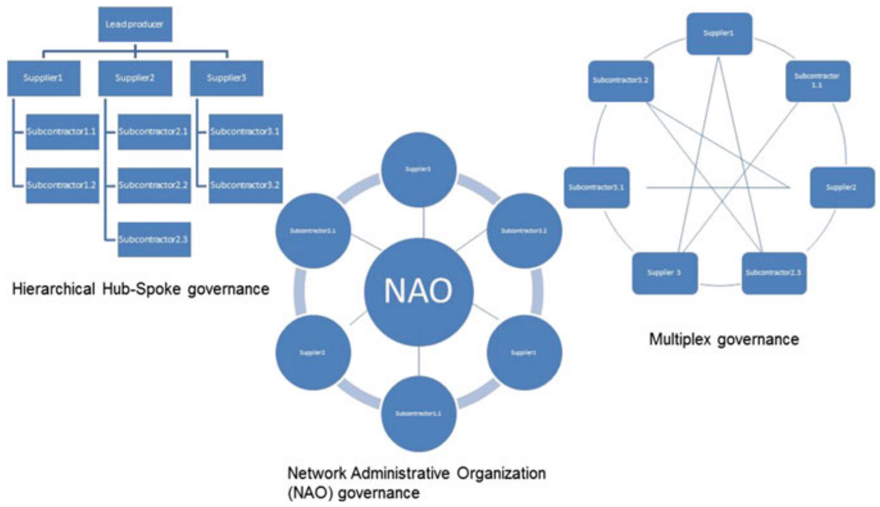

Fig. 4 Network governance models

sharing in the relationship process. This kind of "social contracts" can encourage individual actors to make their best efforts for the whole network as they are manifested in two ways. First, there is a "sense of equality within the various ranks; and second, there is a commitment to allowing people to take initiatives and maximize their potential" (Bitran et al. 2007, p. 37).

Based on their network position and network's governance model, the network actors have different possibilities to participate in network governance. Thus, politics, bargaining, negotiation and compromise become critical control mechanisms because organizations remain relatively autonomous and must be convinced to work together because they cannot be forced to do so (Phillips et al. 2000). So, network's joint goals are always formed within a negotiation process between network actors' own targets and network's goals. Successful coordination in value network requires visibility, patience and deep understanding of networked operations.

Time as well as space matters in networking, because of the dynamic co-production network outcome as well as internal structures and governance models. Thus, network actors must continually invest in the network to ensure its survival and further success. The involved actors should be able to form first a shared understanding about what to do and why to do it, and then to figure out who should do it. Thirdly, in order to answer the question how to do it, different collaboration and governance models can be reviewed. Furthermore, the answer to this third question defines governance structures and the organization of activities at a network level.

Since networks are mostly comprised of autonomous organizations and are not legal entities, the network participants typically have limited formal accountability to network level goals, and conformity to rules and procedures is not governed by binding regulations but is voluntary. For goal-directed organizational networks with a distinct identity, governance is still needed to ensure that participants engage in collective and mutually supportive action, that conflict is addressed and that network resources are acquired and utilized efficiently and effectively. Governance involves the use of institutions and structures of authority and collaboration to allocate resources and to coordinate and control joint action across the network as a whole. Thus, network governance includes different tasks, such as negotiating about shared objectives, aligning the business models of actors, orchestrating value co-creation activities, compromising on multiple values and executing distribution of work. Advantages of this kind of network coordination are considerable: enhanced learning, more efficient use of resources, increased capacity to plan for and address complex problems, greater competitiveness and better services for clients and customers (Provan and Kenis 2007).

5 Governance Models in Different Network Settings

Networks have been studied rather extensively in recent years; thus, it is not surprising that there are several different network typologies. Regarding to the network's structure and objectives, it can be stated that management challenges are markedly different faced by the actors, who try to create new knowledge and future business opportunities in innovation networks, than those faced by the actors in stable, longer-term and well-specified production networks pursuing operational efficiency and knowledge exploitation. The comparison of these challenges is summarized in Table 1 which synthesizes the value network types based on their main tasks. In the context of manufacturing industry, these main tasks are supply or distribution, service and R&D (innovation) operations. Thus, in both the service and the R&D networks, there might be other business ecosystem actors participating to network activities.

In the manufacturing industry, the most typical value networks are hierarchical supply chain networks established to sustain customer satisfaction. As these networks are usually led by large multinational firms or their system suppliers, network governance models are driven by these focal companies through control governance based on business contracts, and the role of other the network actors (suppliers) has received little attention so far. The challenges to network management are often limited to the distribution of explicit knowledge, integration of information systems, control of networked operations and practical understanding (know-how). Hence, the asymmetric relationships of traditional supply networks may require external agents (e.g. third parties and network administrative organization (NAO)) as information carriers to mediate the conflicting interests related to the exploitation of confidential information such as that on costs.

In the middle of the continuum are the enhancing service networks that are relatively well defined, but that can be renewed through incremental and local change processes. From the management challenge perspective, these networks

Table 1 Management challenges at different types of value networks

	Type of network		
	"Traditional supply networks"	"Enhancing service networks"	"Innovation R&D networks"
Network activities	• Sustain customer satisfaction and operational effectiveness • Increasing specialization of each partner's knowledge base • Distribution of production and product specifications, delivery and logistics information • Continuous improvement and performance measurements in network (open books for sharing cost information) • Use of integrated information systems (ERP) • Adapt to environmental changes (reactive sustainability management)	• Sharing the common vision and management views • Common problem-solving and value—creation processes as network • Business Process development • Exploitation of practices regarding "communities of practice" and learning networks • Joint sustainable development through alignment of business models	• Focus on future business opportunities and changes in environment • Broadening of the knowledge base of each partner • Continuous and disruptive innovation • Co-opetition (co-operation between the competitors) • Exploration of knowledge on new business opportunities • Highly differentiated knowledge bases challenge the absorptive capacities • Proactive search for new business opportunities related to sustainability
Network governance	• Rules and practices made by the focal company based on contractual relationships • Efficient mechanisms for knowledge integration	• Shared rules and practices of development and problem-solving • Commitment to network and collaboration culture	• Entrepreneurial and emergent strategies • Social networks and interpersonal relationships

Modified from Valkokari and Helander (2007)

must perform both exploitation of recent operations and exploration of new shared collaboration models. The capability to bridge different social network or communities of practice[5] is essential in creating new specialized knowledge in these networks. Another important issue related to these networks is the commitment of network members and their readiness to participate to network governance and for instance share knowledge. Only firms that succeed in developing organizational routines that co-ordinate the learning process and transform diverse individual and organizational knowledge resources into strategic capabilities or core competencies will be able to use knowledge as a source of sustainable competitive advantage.

[5]The term communities of practice have been initially represented by Wenger (1998).

In the most dynamic innovation networks, sense-making of emerging opportunities, setting agendas and negotiating about shared targets, and co-creating value through knowledge exploration dominate the network management challenges. In other words, the role of tacit knowledge or theoretical understanding (know-why) is there much more pronounced than in stable-supply networks. Still, decentralized governance structures are often utilized in order to empower network actors' participation and gain access to the knowledge dispersed into the network. Innovation within a network of companies requires deep integration between the companies and a change in culture towards readiness and ability to share information. Yet, the innovation network must at the same time be open to emergent and entrepreneurial strategies of the network companies.

6 State-of-the-Art Sustainability in Value Networks in the Context of Manufacturing

There are several partially overlapping approaches that consider sustainability in manufacturing operations from design to end of life cycle. Sustainable supply chain management and stakeholder theory have been the most typical lenses for sustainability in networks related to manufacturing industry. Still, they are discussed separately and integrated views are scarce. Based on the broad literature review, Gunasekaran and Spalanzani (2012) stated that although there are many conceptual frameworks and models to estimate sustainable efforts, in practice their scope is quite limited and they do not consider the whole manufacturing system.

Sustainability in product or service design and development is gathered in Chaps. "Dynamic Drivers of Modern Performance: Values, Stakeholders, and Resources", "Perspectives on Performance Assessment and Management", "An Integrated Performance Framework for Sustainable Manufacturing Networks" and "Maturity Assessment for Systematic Performance Improvement in Manufacturing Networks". Thus, collaborative planning at network level is required in order to design and develop sustainable solutions over the life cycle and there are several tools and methods such as design for sustainability, 3R strategies, green procurement, and eco-efficiency and eco-labelling. Lack of appropriate data on sustainability over the product or service life cycle is one of the main obstacles for their utilization. One key concept emerging as a tool in the evaluation of the environmental impact is life cycle assessment (LCA), still also network approaches and collaboration may offer solutions for collecting and evaluating required information related to design for sustainable products.

The focus of sustainable supply chain management (SSCM) has been on environmental "green" issues both in the literature (for summary, see Seuring and Müller 2008) and in the company-level practices focusing on global sourcing. Although nearly all global 250 companies have had a supply chain code of conduct already for years (KPMG 2008), the approach typically is to guide supplier through

KPI's not to co-develop sustainable business together with them, customers or other stakeholders.[6] Furthermore, efforts are increasingly being made to create traceability,[7] closed-loop supply chain[8] or industrial ecosystems and symbiosis.[9]

Eco-industrial approach highlights the role of industry actors as part of the sustainability development and sustainable solutions. As pointed out by Cohen-Rosenthal (2003), each company-level decision on what materials and energy to use and how to use them is a pixel in the picture of industry's contribution to environmental problems or to their resolution. While current eco-innovations in manufacturing tend to focus primarily on technological advances, organizational or institutional changes have often driven their development and complemented the necessary technological changes. Still, new business models, such as the transfer from supplier to service provider or development partner, have increased due to structural changes in value networks and global distribution of work. Service-based business models typically highlight co-creation with customers and thereby their network perspectives focus on downstream networks. For sustainability, they offer avenues for life cycle thinking at network level, highlighting performance outcomes, maintenance and recycling concepts. Based on formal contracts and constant co-operation, lead producers can control also the sustainability-related activities of direct suppliers, customers and their own workforce. In future, companies will work more together—collaborate—with both their customers and their suppliers when developing new products, as well as the sustainable features of the new products. Thus, their possibilities to influence the decisions of each other increase, e.g. through collaboration they can influence to those choices, which they cannot directly guide through formal contracts.

On the other hand, discussions related to stakeholder theory of the firm (rooted on Freeman 1984) has centred on the definition of stakeholder concept and the classification of stakeholder types in order to describe their influence on firms behaviour and sustainability practices. Still, broader views seeking understanding of

[6]For example, in its annual report PUMA presents the ambitious goals initiated by the PUMA Sustainability Scorecard for their suppliers to reduce 25 % of their environmental KPIs leading up to 2015, including water, waste and energy. To assist its suppliers, PUMA has initiated programs with third-party service providers and arranged capacity building programs in the countries where they do their sourcing. Similarly, NIKE points out its future vision of a closed-loop business model, which includes the upfront design of products that can be manufactured using materials reclaimed throughout the manufacturing process and at the end of a product's life.

[7]For instance, the year 2013 occurred "horse meat scandal" within European food retailing is one example of need for traceability in complex supply networks. Thus, there have been several same kinds of cases, where products have been contained wrong ingredients or the production facilities have been insufficient.

[8]At the moment, closed-loop or reverse systems are still typically isolated from the companies' core business as well as from the value network.

[9]The main principle of industrial ecosystems (or ecology) is similar to closed-loop supply chain, e.g. waste of one process can be used as resources for another process. Industrial symbiosis refers to networked material and energy exchange structures progressing to a more eco-efficient industrial system.

sustainability-based business opportunities, collaboration in stakeholder networks and stakeholders' role as facilitators have emerged lately. Realization of the increasing complexity of the interaction among actors within the business ecosystem and along the value network has emphasized the need for collaborative approaches related to stakeholder participation.

The means of a network's focal company to manage the other stakeholders are more informal than in the management of value network as there are no direct business relationships between the actors. Still, joint projects, strategic alliances and other co-operation models offer possibilities to influence and coordinate the activities of end customers, producers of supplements, governmental organizations, local NGOs—or even competitors. Moreover, tight co-operation with research institutions offers possibilities to control at least partially their work and integrate the results of their work also to sustainability development. Multi-actor collaboration has been considered as the best way to achieve more sustainable patterns of development and to overcome limitations of top-down approaches (Vurro et al. 2009), which has been quite typical in supply chain management in the context of manufacturing industry.

7 Roles of the Different Actors in Value Network and Business Ecosystem

The most successful players have been able to build and maintain integrated approaches in their value networks and business ecosystems, on the basis of long-term co-operation, shared knowledge and joint development of competences both upstream and downstream. Boundary-spanning activities with other actors require understanding of their expectations and objectives. Table 2 summarizes the key players within the value network and broader business ecosystem (see also Fig. 2), as well as presents their roles and objectives related to sustainability in manufacturing. Both individually and collectively, all these actors can influence to tackling the barriers towards more sustainable value networks.

Different communities and forums are new emerging models for co-creation between actors. Their role and importance within manufacturing industry is still unclear and companies are not familiar with them. Anyhow, through communities OEMs and lead producers might be able to configure new kind of relationships and have a significant influence to actors, whose decisions they are not able to guide through traditional co-operation models. Networking and collaboration within communities, open forums and platforms enable lead producers, and OEMs also influence other stakeholder groups, trade associations, governments, international organizations, pressure groups and media. On the other hand, publishing information about own activities is an important means to guide the thinking and decisions of other actors. If the focal company is able to form an interesting and credible development agenda, it might have broader impacts than through control

Table 2 Roles and objectives of main actors of sustainable value network and business ecosystem

Actors	Role	Objectives related to sustainable value networks
Lead producer	Business relationship with direct suppliers and customers	Fulfilling orders, ensuring economic supply chain performance Defining and monitoring environmental and social performance criteria
Direct suppliers and customers	Business relationship with lead producer	Cooperation and integration for supply chain performance Fulfilling environmental and social criteria
Government and Non-Governmental organizations (NGOs)	Exert pressure and offer incentives for value network members	Setting (normative/ethical) policies and standards Informing about requirements Providing training and collaborative settings (platforms, projects)
Individuals	Purchasing or providing goods and services as consumers, investing in business and working as employee	Decision-making criteria for different actions Participation to development activities or pressure groups, acting as citizen
Research institutions and universities	Creating new knowledge and understanding	Providing new models, tools and technologies for sustainable development Analysing what works and what does not Disseminating public knowledge
The media and other trend setters	Raising awareness and need for change	Influencing to social and cultural norms related to sustainability

governance. Still, this requires a new approach to management of networks as well as new collaboration structures and integrating actors.

For network governance, it is crucial to understand the other involved actor's expectations, objectives and interest in order to orchestrate their actions through informal and formal activities. Aligning these different expectations is a complex process and that is one reason why business ecosystem is typically co-evolving slowly. Anyhow, collaboration generates multiple values at different levels (from individuals and organization at micro-level to society and environment at macro-level) in part because these interactions and collaborative actions occur at several levels. Still, companies could have a more active role in facilitating this evolution, if they are able to use different collaboration models simultaneously. On the other hand, it is also important to consider how there are several value networks that are partially competing and at the same time co-operating with each other.

Through these multiple networks, companies can create innovative and dynamically evolving sustainability initiatives, if they are willing to put efforts to network governance and open-minded when choosing partners and collaboration models. Furthermore, also policy-making requires the concerted efforts of multiple actors, all possessing important capabilities but are dependent on each other in order to solidify intentions and convert them into actions.

Network or stakeholder orientation alone, however, does not deliver sustainable governance. The models presented earlier presume that broader stakeholder involvement will lead to better decision-making of the executive through transparency. If the employees owned the business, for example, then the social dimension of performance becomes critical, and we have many examples where this type of ownership results in overall better business performance, including higher productivity and higher profitability. These governance models do not seek only representation of other stakeholders but full inclusion in the executive such that previously external costs (such as pollution) are internalized by the executive team.

8 Network Governance Model for Sustainability

The main challenges of governance for sustainable development differ according to network type (as summarized in Table 1). In traditional supplier networks, sustainability governance is based on focal companies supply chain code of conduct and global sourcing practices. In service networks, joint sustainable development is governed through the alignment of business models and network members' commitment to shared problem-solving is important. In loosely coupled innovation networks, governance is often decentralised; e.g. proactive search for new business opportunities related to sustainability occurs through social networks and interpersonal relationships. Similarly, co-operation level varies from strategic initiatives and partnerships related to innovation to operative arrangements in the management of supply operations.

In their unifying "Framework for Strategic Sustainable Development (FSSD)", Robèrt et al. (2002) identified five planning levels towards sustainability: (1) understanding the system, (2) defining what success means within the system, (3) guidelines to ensure that actions taken are strategic, (4) evaluate all actions against strategic guidelines and (5) consider tools to support these actions. Although there are already several practical experiences from using the FSSD, little has yet been made to study the FSSD framework utilization at value network and business ecosystem levels.

Network governance deals with many important questions, which are similar to key aspects presented also at the FSSD framework. As summarized in Fig. 5, the key questions are: "how is the governance structure organized—is governance shared or does it have a leading organization (typically focal company) or perhaps a "third party" that works as an administrative organization?", "What are the governance mechanisms—are they governed by contracts or relational norms, or how

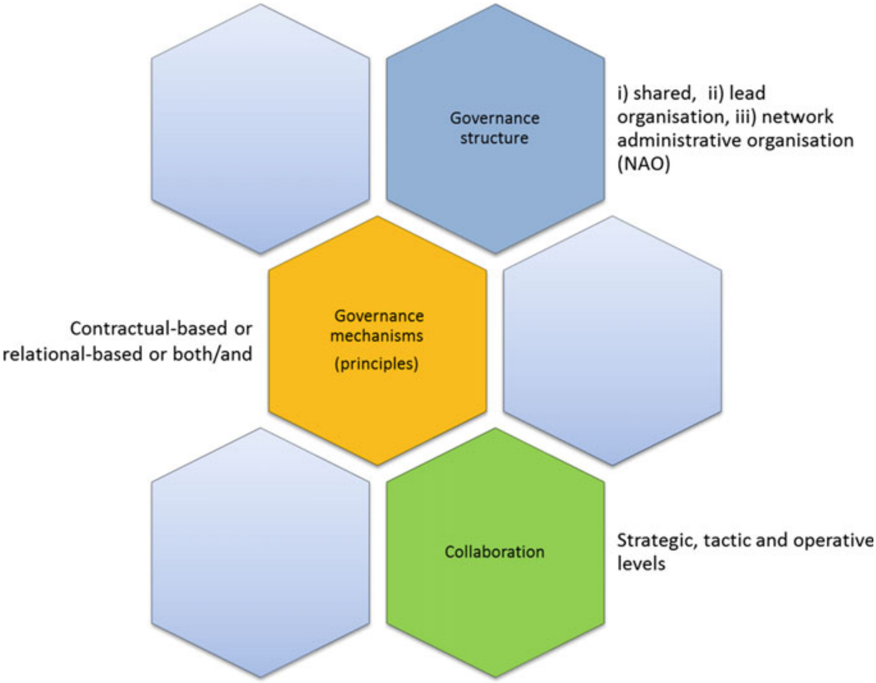

Fig. 5 Elements of network governance

are these combined?" and "To what levels do network governance, collaboration and decision-making extend—strategic, tactic or operative issues?". Thus, understanding system (network) and its borders as well as the success factors is the starting point for network governance.

In accordance with company-level approaches, the network governance model includes three main tasks—analysing, organizing and developing

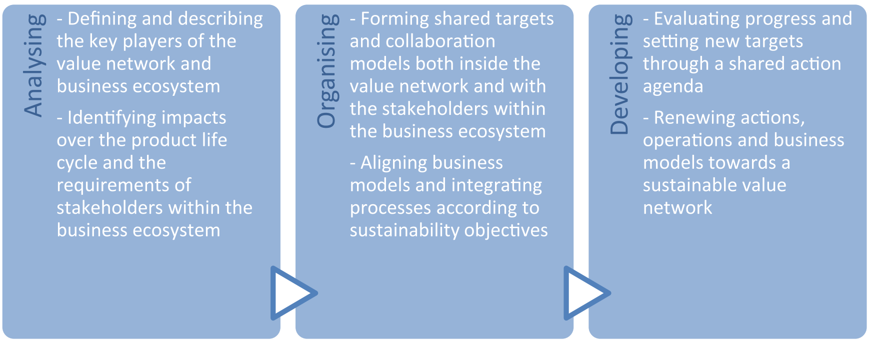

Fig. 6 Main tasks in network-level governance model

(Fig. 6).[10] In the analysing phase, the aim was to create joint strategic sustainability objectives within the value network based on analyses and understanding the interests of all the actors involved (both the network and the stakeholders). Then, in the organizing phase, the network actors agree on the organizing (e.g. network structures, roles and responsibilities) within the network in order to be able to coordinate the actions. Thirdly, in the developing phase, the network actors continuously work together to develop the joint objectives and evaluate the progress and required changes.

In order to guide the activities of all the actors involved towards the sustainability objectives, companies must first define the key players inside the value network and the boundaries between the network and the business ecosystem in *the first phase of network governance model*. This network analysis requires the connections (e.g. business relationships, informal collaboration and ownerships) between the actors to be pictured. In order to do so, the network members need to understand the network's value to each member, and their objectives, self-interests and expectations should be covered. Concurrently, the requirements and expectations of important stakeholders within the business ecosystem need to be defined. Based on these initial analyses, companies can identify the total sustainability impacts over the product life cycle and the requirements of all the actors involved. Furthermore, network structure analysis provides understanding about links between the actors, structural holes in network and possible sub-networks. This knowledge about network structure helps actors to predict how and by whom knowledge sharing, mutual sense-making and negotiations will occur in value network. In this phase, the key questions are the following:

- Which participants from value network and business ecosystem should be engaged in sustainable development?
- What are the role, objectives and requirements of involved actors?
- How can the actors be motivated?
- What are the impacts of shared sustainability agenda over the product life cycle?

Within the first phase, these analyses help firms achieve a deep multi-level understanding of involved actors, their objectives and thereby define processes and cross-organizational activities needed for sustainability at value network level. Thus, cross-organizational teams are typically needed in order to support communication, brainstorming and collaboration between the involved organizations.

The analysis of the actors involved and the understanding of their requirements direct the organizing and managing of sustainable development at network level *the second phase of network governance model*. Shared targets and collaboration models are formed both inside the manufacturing network and towards other stakeholders within the business ecosystem. In this phase, an important aspect of

[10] A workbook, entitled "Towards sustainability governance in manufacturing networks" summarizes the appropriate tools. It can be accessed: http://www.sustainvalue.eu/publications/SustainValue_Governance_Workbook.pdf.

the sustainability governance in value networks is the connection between sustainable development and business models. Thus, aligning business models and integrating processes according to the sustainability objectives should be considered carefully. Complementary resources and knowledge is key aspect in network formation; thus, network governance model ensures pooling organizational resources in ways that improve network's ability to solve customer's problems, enhance services or produce and deliver products.

In order to ensure continuous improvement as well as renewal, progress should be evaluated through a shared action agenda, and new targets should be set transparently based on the achievements. "Maturity Assessment for Systematic Performance Improvement in Manufacturing Networks", presents performance measurement tools that can also be utilized in order to form network's shared targets for sustainability. Thus, use of frameworks and tools that participants are familiar with may support their active participation. In this developing phase, actors should renew actions, operations and business models together to become a truly sustainable value network in the manufacturing industry. Still, value network and its surrounding business ecosystem are dynamic and complex, because of interconnected relationships that change over time. This causes uncertainty that is a formidable governance challenge. One way to cope this uncertainty is to support shared sense-making and knowledge sharing within the value network. In this phase, the key questions are:

- How to generate and facilitate interaction about sustainability at different levels of the value network and business ecosystem?
- What are the appropriate tools and methods for boundary-spanning development of the shared "win–win–win" approach for sustainability?
- How to manage joint processes? Do the network structure and collaboration model facilitate the knowledge sharing and sense-making between the members?

In this phase through sense-making process, organizations are building agreement on common facts, theories and methods. Knowledge is often dispersed in networks and thereby integration of knowledge bases or information systems, and other forms of knowledge sharing are important issues regarding network governance.

Whereas the first two phases of the governance model concentrate on building up and developing the sustainable value network so that it really fits and works together, *the third phase of network governance model* focuses on the network as an entity and, thus, also discusses its relationship with external stakeholders, the environment and the whole ecosystem. The future structure and performance of a network are co-produced by the actors involved, and the governance of the network level activities is thereby more or less self-sustaining and evolving. Through network governance, collaborative organizations ensure that interaction is concurrent over the product life cycle, which in turn promotes development of strong social community. In this phase, the key questions are:

- Have we gained progress and what should we do next in the sustainable value network and business ecosystem?
- How do we make other actors (external stakeholders, outside our value network and business ecosystem) to collaborate for sustainability challenges together?
- What are the future needs and development steps towards sustainability? Do we need new members or models to work towards these objectives?

In that way, collaborative actors can also improve value network's capacity to co-operate within the business ecosystem and over the sectorial boundaries. Collaboration over network boundaries is required also to restrain network's inertia to limited level, as the present business environment is turbulent also the network must be able to proactively change. In other words, networks and their governance should be distinguished from firms by certain temporariness; e.g. when the joint goals are achieved, the value network can break down. The recognition of complex nature of sustainability challenges may lead companies even step further from value network to ecosystem management, which aims to getting actors to realize that they all are part of the ecosystem—not separate units from it.

9 Conclusions

Moving towards sustainability means that companies and their value networks need to be aware of their role in meeting also the macro-level objectives (see Fig. 1), although they do not necessarily have a direct influence to them. For sustainability at the network level, the scope of analysis needs to go beyond customers, immediate partners and shareholders. This involves identifying all stakeholders, their relationships and value exchanges, to gain precedence in the development of sustainable business models. This implies the need for improved and broader understanding of multi-stakeholder value, and the need to seek opportunities for alignment and exchanges between stakeholders in the value network. Thus, there is a need for better visibility of stakeholders in the value network for the development of sustainability and new sustainability-based business models in the context of manufacturing industry. Furthermore, there is also the temporal dimension in the co-creation of sustainable value; for example, multi-stakeholder value may be generated within different timeframes. Thus, in order to foresee the business opportunities and possible development paths, it is crucial to understand the interests and motivation of all involved parties. In this multi-level evolutionary process, the network level value mapping could have an important role to recognize the hidden values and thereby explore new business opportunities.

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Products and Services in a Sustainable World

Christian Grefrath, Dirk Wagner and Sebastian Stermann

1 Introduction

Globalisation has activated a new industrial revolution, leading to a worldwide distribution of production and markets. The increasing demands for sustainability, however, have created new challenges and emerging opportunities for society and for business. In line with increasing international trade, the need to transport raw materials, energy, components, intermediate products and goods increases. The traditional transnational ways of manufacturing products and delivering services cannot be sustained in the emerging eco-sensitive business environments, where growing trade volumes and commercial operational patterns impose significant environmental challenges. This is for example evident in the greenhouse gas emission footprint related to production, logistics, transportations and other internationally operating network-related activities. Therefore, the society has to find answers how to design products and services in a more sustainable way.

In this chapter, the trend in manufacturing and service industry towards sustainability is introduced and its challenges are shown. In a next step, a new trend—the combination of products and services (PSS), also called solutions—is

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introduced. After introducing the idea of product service systems, the necessity for an integrated development framework to develop them in a sustainable way is demonstrated.

2 Concept of Sustainability

The concept of sustainability first appeared in the context of the Green Movement during the 1960s resulting in the formation of influential non-governmental organisations like Greenpeace. Whereas in the beginning the idea of sustainability included primarily ecological aspects, it has evolved into a broad concept with high relevance for today's management across all industries (Bhamra and Lofthouse 2007). Today and within the EU-funded Sustain Value project, the definition of sustainability is a state that requires that humans carry out their activities in a way that protects the functions of the earth's ecosystem as a whole. It affects three fundamental dimensions (economic, environmental and social). The following Fig. 1 shows the different aspects of each dimension.

These three dimensions provide an important area for requirements concerning the advised solution development process. Direct requirements and characteristics can be deduced from these fields. It has to be noted that three factors can work contrary as well as complementary to each other depending on the individual case. Today, sustainability is a core element of any entrepreneurial activity. For example, sustainability can be reached by accompanying products during the whole life cycle.

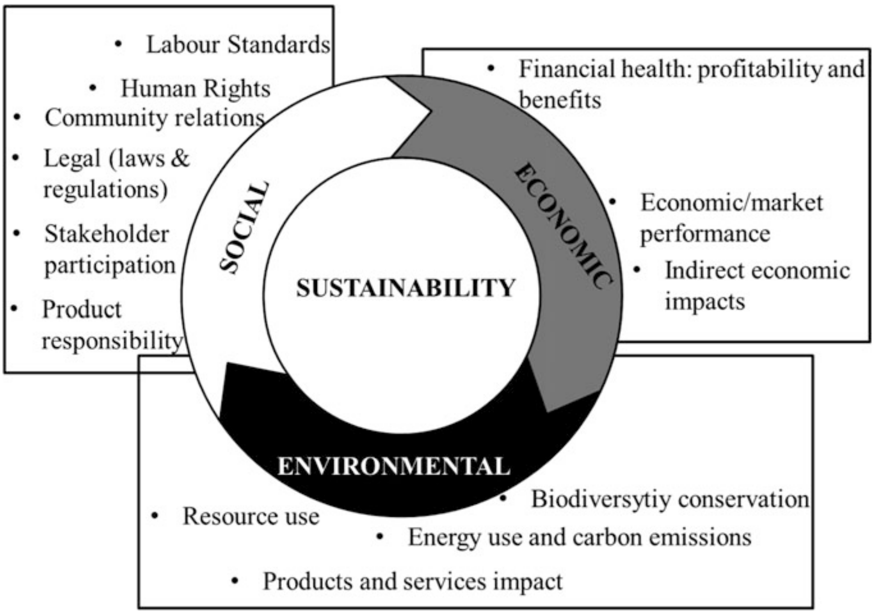

Fig. 1 The three aspects of sustain value (adopted from Elkington 1997)

3 New Developments in the Manufacturing Branch

To be successful and resilient in this ever changing business environment, manufacturers must be proactive. Industrial practitioners need to be creative in recognising the opportunities that the sustainable economy will present for development of new products, identification of changes in markets and optimising their internationally operating network according to the new sustainability criteria. A concrete way for exploiting these opportunities is the development and implementation of new sustainability-based industrial models and concepts.

Key challenges related to sustainable manufacturing networks (adopted from Jovane et al. 2008)

- Sustainable manufacturing must respond to
  - economic challenges, by producing wealth and new services ensuring development and competitiveness through time;
  - environmental challenges, by promoting minimal use of natural resources (in particular non-renewable energy) and managing them in the best possible way while reducing environmental impact;
  - societal challenges, by promoting social development and improved quality of life through renewed quality of wealth and jobs.
- At the enterprise level, products and services must be
  - safe and ecologically sound throughout their life cycle;
  - appropriate, designed to be durable, repairable, readily recycled, compostable or easily biodegradable;
  - produced and packaged using minimal amounts of most environmentally benign materials and energy;
  - transported, stored, delivered and commissioned for use in an eco-efficient, economic and socially responsible manner.

Enterprises must take into consideration not just the economic goals but also the need to now simultaneously meet environmental and social goals in carrying out business; recognising that economic, environmental and social impacts occur at all stages in the value network, including during customer use. This implies not only being able to manage internal activities and operations of the producing organisation, but also getting all the value-network partners to follow the same principles and performance standards that have implicit or explicit influence on the sustainable product and service delivery performance. Sustainable value creation is the key contribution of enterprises to sustainability, i.e. to create long-term value on an economically, socially and environmentally sustainable basis.

4 Product Service Systems as an Enabler for Sustainability

In order to succeed in a globalised economy, companies are required to move beyond the traditional business model of "make and sell" physical products. They have to sell new offerings that additionally include services as the key factor for competitive advantage (Bullinger and Scheer 2006). In particular, large industrial corporations of the manufacturing industry need integrated solutions, so called product service systems (PSS), to sell their original products profitably and drive revenue growth.

Across academia, there exist multiple definitions of product service systems within the context of sustainability. Brezet for example (Brezet et al. 2001) states that "Eco-efficient services are systems of products and services that are developed to cause a minimum environmental impact with a maximum added value". According to Belz et al. (1997), integrated product service systems combine physical products and services as defined in ISO 26000:2010 (Guidance on social responsibility) to address new market demands and meet requirements holistically and more economically. On the other hand, individual customer offerings are often simply consist of a "comprehensive bundle of products and/or services, which fully satisfy the needs of a customer related to a specific event or problem" (Stremersch et al. 2001). A solution should not be understood as a simple combination of both product and service, but as a hybrid product that cannot be precisely deconstructed again. A hybrid product is defined as a bundle of products and services that consists of an individually adjusted combination of product and service components tailored to customer requirements (Burianek et al. 2007). The drivers for transition to a service-orientated model are generally strategic moves to create a new value proposition for competitive advantage, often when differentiation on product features or cost is growing increasingly difficult to maintain. The service-based model, largely labour and knowledge based, offers an opportunity to create a competitive advantage that is less easily emulated by competitors as the experience and skills earned by the employees in the process. Service provision cannot be easily copied in a way a technical feature can. Additionally, the service approach automatically builds a closer relationship with the customer, providing opportunities for customised services and enhanced customer value, creating customer loyalty, better chances of repeat business and greater barriers to entry of competitors. Furthermore, in a world of specialisation and outsourcing, many customers are specifically looking for total solution providers; hence, being able to offer a service is a strong marketing tool.

In the following, some examples of successful PSS are explained.

PPG Industries (Rothenberg 2012)

PPG Industries Inc. is a coatings manufacturer. In the 1990s, PPG was faced with Chrysler's demand for reductions in product use as a result of two main drivers. Chrysler wanted to cut costs on the one hand, and on the other hand, they had to fulfil new environmental regulations. The strategic response for PPG was to help its customer reduce paint use.

PPG on-site representatives started to take over new management tasks at the plant. They participated in tasks such as material ordering, inventory tracking, inventory maintenance and regulatory-response duties. Through this increased service role, the company has helped Chrysler reduce material use.

Aerospace Industry (Baines et al. 2009)
Engine manufactures in the aerospace sector such as Rolls-Royce, General Electric and Pratt & Whitney developed a new business model. Instead of selling turbines to airlines, they now offer performance-based contracts. They provide the service for their engines like maintenance. By that they do not sell engines but product availability. Such contracts provide the airline operator with fixed engine maintenance costs, over an extended period of time (e.g. ten years) and enlarge efficiency of the engines.

4.1 Advantages of PSS

Sustainable solutions are more complex than traditional product service systems. While economic sustainability can easily be measured through key indicators such as revenue, profit or market share and the growth thereof, social and environmental aspects are more complex. Generally, PSS offer potential environmental benefits. Zaring et al. (2001), who studied product service systems in a business-to-business context, discuss two main factors driving environmental benefits: first, the creation of intangible value by dematerialisation through more productive utilisation of assets, and secondly, a change in user and producer behaviour encouraged by the PSS. Wong (2001) notes a list of potential benefits. Environmental benefits can include the following:

- Development of better end-of-life disposal processes, as there will be clear pressure to design for this stage of the product life cycle from the start of the concept generation phase onwards. Manufacturers incentivised to develop innovative uses for end-of-life products
- Easier upgrading to more eco-efficient technologies.
- Manufacturers, which are also the main operators of the PSS, will have no incentive to sell excess material, will also be in a better position to optimise the products for their true function, will have far better knowledge regarding the true requirements and characteristics of the equipment.

Social sustainability requirements of a PSS are even less understood, especially in a non-macroeconomic context. Tukker and Tischner (2006) note multiple social benefits while noting potential negative social impacts such as degeneration of employee or customer skills and outsourcing of labour to low wage countries. Potential benefits include the following:

- PSS can strengthen the role of the local economy because services are created at the same time and often at the same place when and where they are consumed. This may also contribute to enhancing social coherence in the region.
- Use- and result-oriented PSS have a revenue model that does not require payment for the full value of the product upfront—a relatively small payment is asked for every use or every time a result is delivered.
- PSS may integrate customers directly in the generation of the PSS and address special customer groups or needs that otherwise would be neglected, thus empowering consumers.

4.2 Necessity for an Integrated Development Framework

However, the challenges in transitioning to a PSS-based business model are significant. For an OEM used to selling discrete products, it can be difficult to develop somewhat 'fuzzy' intangible service solutions, some industries, especially those selling components in the B2B market such as steel mills, will find it difficult to even identify value adding services. The new business environment may be more complicated and different, with unexpected competitors outside their usual sphere of business pushing into the market. Entering new markets that before were served primarily through product exports alone requires competent local staff, that in many cases has to be trained and educated first. Furthermore, PSS places a major financing burden/cash flow issue on the PSS provider because rather than buying the product up front the user might only pay fees over an extended period of use. There are associated financial and business risks associated with contractual default/bankruptcy of users. Significant barriers to adoption may exist, including consumers' lack of enthusiasm for 'ownerless consumption' or shared communal assets, and the challenges of building distribution/service networks at scale. This is especially true when comparing different markets. Whereas urban residents in developed nations are moving away from private car ownership towards car sharing schemes, the prestige associated with private car ownership is driving car sales in emerging markets.

More and more enterprises are taking partial steps towards the goal of sustainable solutions, but they are not using a comprehensive approach to manage sustainability at the value-network level and inevitably deliver sub-optimisation at best. Individual businesses cannot deliver the system changes required at the value-network level. Collaboration among partners with respect to economic, ecological and social sustainability can and must be enabled by developing attractive and common approaches for sustainable production and services.

4.3 Process of PSS Development

The Chap. "Development Methodology for Sustainable Solutions" in this book deals with the development of sustainable solutions that ensure maximum value of products and processes through the complete life cycle. The development of a framework for sustainable development solutions was part of the Sustain Value project which is described in the chapter below. In the Sect. 4 in Chap. "Development Methodology for Sustainable Solutions", a development methodology is elaborated, which allows a step-by-step development in order to create goal-orientated solutions. For a complete and successful application of the development methodology, the developers need applicable tools and methods to develop sustainable solutions.

In Sect. 3 in Chap. "Methods and Tools for Sustainable Development of Products and Services", a tool and method box for a structured and efficient development process is presented. The tools and methods presented in there will provide companies with the necessary equipment for the analysis and optimisation of their processes in order to improve sustainability. The tools are selected according to the constraints given by the industrial context and life cycle phases considered in the industrial partner premises. Otherwise, the tool and method box consider the applicability of the tools in co-development context in value networks.

In addition, Sect. 4 in Chap. "Methods and Tools for Sustainable Development of Products and Services" shows a possible development path and the suitable tools for application, which can be used as a guideline for companies and value networks to evaluate and optimise their current business processes. Together with the methodologies described, the presented toolbox helps a developer in a company or value network to develop sustainable solutions. It assures a structured and systematic approach by giving tools that are needed for a complete and successful sustainable solution.

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Part II
Business Modelling for Sustainable Manufacturing Value Networks

Businesses are increasingly embracing approaches to sustainability such as eco-efficiency, corporate social responsibility (CSR) and cleantech. However, such innovations and approaches are not sufficient to address sustainability. More fundamental changes in the way industry and companies do business is required. This implies rethinking the business model to deliver sustainability. Existing business models and modelling activities predominantly focus on generating economic value through focus on interests of customers and shareholders. Core to such an approach are assumptions of infinite growth and the inherent throughput of energy and resources demands. To integrate sustainability into a business, a comprehensive consideration of a broader range of stakeholders across the manufacturing networks is necessary to rethink the value proposition of a company for the environment and society. Design and development of tools that explicitly include a multi-stakeholder view of value is seen as being integral towards business model innovation for sustainability. This part provides overview of business models, value network and sustainable business models followed by a practice review based on six case studies, whilst highlighting the observations and gaps in literature and practice. The part concludes by illustrating the sustainable business modelling process and toolset to assist companies and practitioners in redesigning and developing business models for sustainable manufacturing networks.

Business Models and Business Modelling: State of the Art

Padmakshi Rana, Samuel W. Short, Steve Evans and Maria Holgado Granados

1 Introduction

Sustainability is increasingly recognised as a pressing problem facing the modern world. Climate change, resource depletion, social responsibilities of companies—working conditions and practices, community relations, increasing inequality, and persistent poverty and health issues in many parts of the developing world and other growing environmental and social problems illustrate the unsustainable nature of production and consumption across the world. These challenges that shape the mainstream thinking on sustainability require strategic and operational changes to businesses. Authors, such as Krantz (2010), Munasinghe (2010) and Evans et al. (2012), suggest 'sustainability as an innovation platform' for a fundamental shift towards a sustainable economy with significant changes in people's lifestyle and mindset/behaviour, redesigning business models and value networks 'to embrace a transformational sustainability that moves beyond incrementalism and ecoefficiencies'. Hence, the transition towards sustainable manufacturing networks will require a significant shift in the way businesses are conceived and operated through collaboration among stakeholders in the value network to generate sustainable value (environmental, social and economic).

The majority of business model literature, although comprehensive, is largely focused on the economic view of the company for financial profit and growth, while guiding thinking in economic directions. They do not explicitly embed sustainability

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value and objectives in business model innovation and are limited in the inclusion of a broader range of stakeholders in the value network. However, they do provide frameworks for analysis of existing business models and innovation, and offer good insights into the development of more comprehensive tools to guide creation of business models for sustainability. The following sections will elaborate on the business model and value literature, in particular business model innovation, business modelling frameworks, stakeholders and value network followed by a discussion.

2 Business Models

The business model concept provides a basis for creation of tools and frameworks to assist business managers and researchers in investigating business models. These tools serve a number of potential functions (Osterwalder and Pigneur 2005):

- Capturing, understanding the relevant elements and interactions, and sharing the business model concept,
- Undertaking analysis to measure performance, observe and compare with others,
- Management—the business model concept assists in the design, planning and management of change of the value creation logic of the company,
- Innovation of business models—assist in prospecting for new business models through structured design and simulation.
- Patenting of models

Business model in simple terms depicts 'how a firm does business' (Magretta 2002). All companies have some form of business model, even though they might not explicitly have considered or defined their model (Teece 2010). Business models have received substantial attention in the literature and industry, with a particular focus on e-businesses, whose growth has consequently been one of the drivers in the drawing attention to the area (Richardson 2008; Teece 2010). The term first appeared in the academic literature in the 1950s, but discussion of business models really gained prominence during the dot-com era of the late 1990s (Zott et al. 2011). Prior to this, the majority of business models were arguably fairly self-evident. However, the 1990s saw companies experimenting with novel models for creating, delivering and capturing value from the Internet-based knowledge economy. This interest has continued to grow, and the business model is now increasingly recognised as a new unit of analysis in the literature used for both explaining existing company performance and exploring new configurations (Zott et al. 2011). E-business has been the most prominent focus of business model research. Interest has also been driven by demand for bottom-of-the-pyramid solutions for emerging markets and companies in post-industrial technologies (Zott et al. 2011). Research into business models for sustainable solutions based on renewable energy, eco-innovation and social entrepreneurship is gaining prominence.

Despite the widespread use of the term 'business model' in academic and non-academic literature, there is a lack of clarity around the definition and a lack of conceptual consistency (Magretta 2002; Chesbrough and Rosenbloom 2002; Zott et al. 2011). Below are some key definitions from the business model literature:

- The model depicts the content, structure and governance of transactions designed so as to create value through the exploitation of business opportunities (Amit and Zott 2001)
- A business model fulfils the function of value proposition, market segment, value chain, revenue mechanisms, cost structure and profit potential, and position of a firm in the value network and formulates competitive advantage (Chesbrough and Rosenbloom 2002)
- The design or architecture of the value creation, delivery and capture mechanism of a firm—how the firm delivers value, how it attracts customers and how it converts this to profit (Teece 2010)

The confusion in part is because the term is used interchangeably to mean different things. It is used to describe:

- Representations of firms operating models (e.g. 'razor-and-blades' model).
- Elements of a business model (e.g. revenue model, value proposition, key resources, channels).
- Operating business model (complete firm-specific representations of all elements of the core logic of the firm's value creation system).

The academic debate over business model definition arises in part because of the various frameworks (see Sect. 4 below) that have been conceived to address specific industries or orientations, rather than due to fundamental difference of opinions. Business models guide and underlie business strategies and innovation (Machiba et al. 2012). However, they are economically driven, focusing primarily on 'competition and market expansion'. Nonetheless, the innovation in business model in order to integrate sustainability could be rethinking the value proposition to include environmental and social goals. Furthermore, business model definitions in the literature generally exclude governance, performance metrics, and management processes, and investment structures—all of which are potentially highly relevant to achieving sustainability. The following sections will present the discourse on variations between business model, business strategy and business architecture.

2.1 Business Model, Business Strategy and Business Architecture

A review of the literature (Al-Debei and Avison 2010; Magretta 2002; Chesbrough and Rosenbloom 2002) illustrates how the term 'business model' is often used interchangeably with 'business strategy', or alternately conceived as an element of strategy, or sometimes even as an overarching construct that embodies the strategy. This is perhaps due to the theoretical underpinnings of business models, where articulated, build on central themes in business strategy—value chain concept, resource-based theory of firms, strategic network theory, cooperative strategies, Schumpeterian innovation and transaction cost economics (Amit and Zott 2001; Morris et al. 2005).

Magretta (2002) suggests that the confusion in part reflects the lack of consensus around the concept of strategy itself. The author attempts to differentiate the two by delimiting the concept of strategy to competitive considerations and the business model to collaboration and value creation, but concedes that the business model may sometimes act much like a strategy. Chesbrough and Rosenbloom (2002) similarly conceptualise the business model around value creation and delivery, and strategy around value capture and competitive positioning. Casadesus-Masanell and Ricart (2010) observes that the business model and strategies are often direct reflections of each other and hence difficult to separate conceptually. Furthermore, the conceptualisation of a business model must by necessity involve strategic considerations if it is to be successful in a competitive environment; hence, the two cannot be considered independently (Teece 2010).

A company's business strategy could therefore be represented by numerous business models, and equally an abstracted business model could be applied to multiple firms; strategy on the other hand is highly specific to the individual firm and its environmental context. Rather than attempting to delineate elements as either strategy or model, the business model could perhaps be viewed as a conceptual tool that serves as the link between business strategy and implementation.

Osterwalder (2004) argues that the business model and the business strategy talk about the same issues but in different business layers and at different organisational levels. Hence, Fig. 1 illustrates the link between business model and business strategy through the organisational layer lens, which makes an attempt to illustrate the variation.

A further area of confusion around the use of the term 'business model' is in relation to the terms 'business architecture' and 'enterprise model'. The terminology and majority of the literature in this area come from the ICT sector. Osterwalder and Pigneur suggest that the business model and enterprise model are conceptually very close. The main difference between the two is that the enterprise model is mainly concerned with processes and activities, whereas the business model focuses on value creation and delivery to customers (Osterwalder and Pigneur 2005). The business architecture as conceptualised by Versteeg and Bouwan (2006) is 'to structure the responsibility over business activities prior to any further effort to structure individual aspects (processes, data, functions, organization, etc.)'. They specifically differentiate between business architecture and enterprise architecture by emphasising the fact that the latter is specifically about the processes and systems within an individual enterprise/firm.

Overall, the subject of architecture seems less well developed than that of business models. The business architecture forms the link between business model

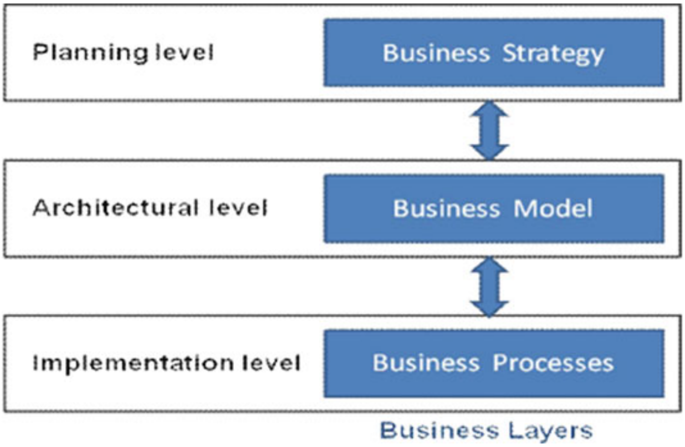

Fig. 1 Different layers within a business and their associated levels (adapted from Osterwalder 2004; Bask et al. 2010)

and strategy, that is, the business model acts like the blueprint for a strategy that is implemented through organisational structures, processes and systems, which is the business architecture. Focus at the architecture level enables additional issues to be considered to support business models in delivering sustainability. Specifically, corporate culture as defined by norms and values, recruitment and training, performance management systems and governance structures—all seem likely to be relevant in developing successful sustainable businesses. This might potentially prove to be an important addition to the modelling process supported by business model innovation. The next section will provide a brief overview on the need for business model innovation.

3 Business Model Innovation

The literature (Chesbrough 2010; Zott and Amit 2010) suggests that business model innovation is a key to business success. 'Business model innovation is a multistage process whereby organizations transform new ideas into improved business models in order to advance, compete and differentiate themselves successfully in their marketplace' (Eppler and Hoffman 2011). Some scholars argue that technology and process innovation alone are no longer enough to create sustained competitive advantage, and the business model itself is key to unlocking the latent value potential of new technologies (Chesbrough and Rosenbloom 2002; Teece 2010). Empirical studies seem to give some support to this, suggesting that firms that are financial outperformers put considerably more explicit focus on business model innovation (Zott et al. 2011).

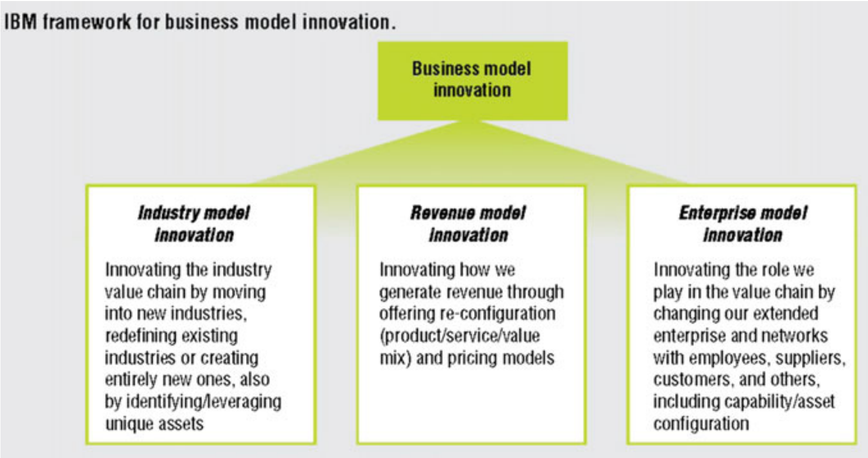

Fig. 2 Business model innovation (Giesen et al. 2007). *Source* IBM Institute for Business Value and IBM Global Business Services

Chesbrough and Rosenbloom (2002) suggest a need for firms to dynamically experiment with innovative business models and to have a willingness to continually reshape models as their business develops over time. This is perhaps particularly relevant to the sustainability agenda as business models may need to continuously evolve to address tightening regulation, contracting resource supplies, climate change effects and shifting social pressures. Giesen et al. (2007) suggest a typology of three types of business model innovation, and their findings suggest that all three types can generate success. They suggest enterprise model innovation, that is innovation in the value network, is particularly effective for mature businesses (Fig. 2).

Johnson and Suskewicz (2009) argue that the key to large-scale systemic change, such as that required for a transition to renewal energies, is to shift the focus from developing individual technologies to creating whole new systems. The business model concept and business model innovation at the industry level are key to this process. Johnson et al. (2008) and Johnson (2010) observe that business model innovation can be driven by market catalysts, larger industry-wide changes and competition:

- The opportunity to address through disruptive innovation the needs of large groups of potential customers who are shut out of a market.
- The opportunity to capitalise on a brand new technology by wrapping a new business model around it (e.g. Apple iPod/iTunes).
- The opportunity to bring a ‘job-to-be-done’ focus where one does not yet exist.
- The need to fend off low-end disrupters.

- The need to respond to a shifting basis of competition.
- Unpredictable and radical shifts in market demand.
- Discontinuous shift in technology.
- Dramatic shifts in government policy.
- Performance-based competition → product innovation.
- Reliability-based competition → process innovation.
- Convenience-based competition → business model innovation.
- Cost-based competition → business model innovation.

Some scholars have observed that radical innovation may be more likely to come from new start-ups rather than the large established incumbent corporations, citing Google, Amazon and Facebook as examples; Xerox Park and Kodak are cited as examples of large incumbents failing to adopt radical innovation. If true, this phenomenon may be because existing production facilities, business relationships, suppliers and distribution channels and partners act as significant structural barriers preventing established firms from radical innovation (Teece 2010). The dominant logic within large firms may also preclude identification of new business models that differ substantially from the firm's current model (Chesbrough and Rosenbloom 2002). A number of further factors that may prevent large firms from innovating are (Christensen 1997; Christensen et al. 2010) as follows:

- Inability to enter emerging markets because cannot satisfy internal growth demands.
- Markets that do not exist cannot be analysed.
- Technology supply does not always equal market demand.
- Large customers define resource allocation—not the management.
- Use of discounted cash flow and net present value tend to overdiscount the value of new innovation relative to existing business.
- Treatment of fixed assets and sunk costs tend to inhibit innovation.
- Emphasis on short-term earnings per share.

In practice, large companies due to the scope of their operations, and depth and breadth of resources, including financial resources, perhaps have more scope to move into different market spaces. In addition, large companies often attempt to mitigate the above barriers through the creation of smaller business units or independent businesses. Furthermore, innovation in accessing information is useful for communicating about sustainability and its impact on life cycle phases, for example ICT technologies. Figure 3 provides a conceptualisation of industrial sustainability and represents the various pillars, their factors with an emphasis on the role of innovation and globalisation being central to driving change in existing business models. It emphasises the important role of job creation and wealth distribution.

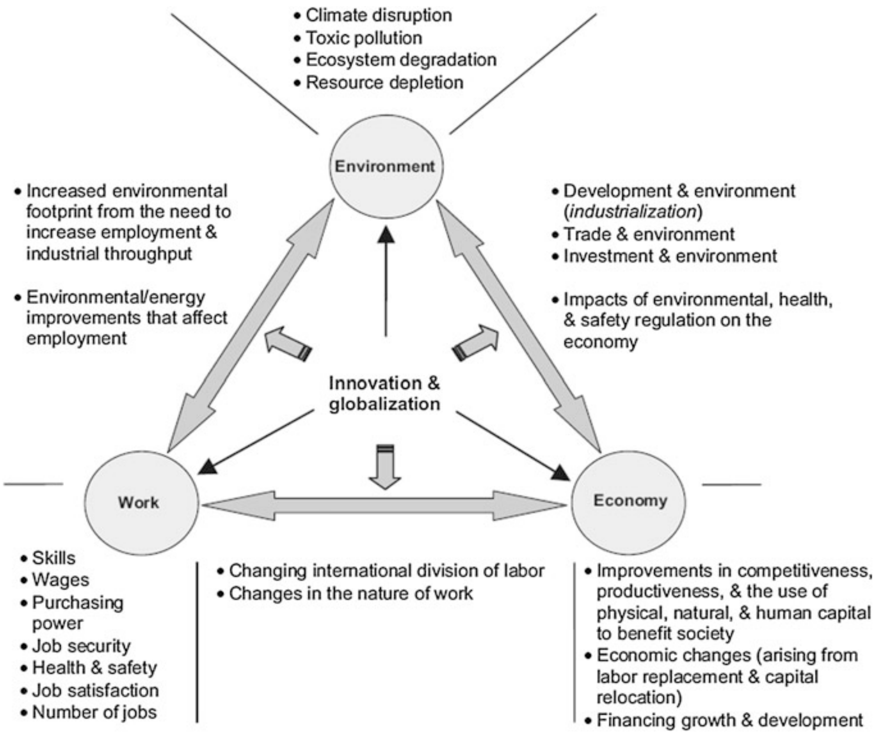

Fig. 3 Innovation and globalisation as drivers of change within and between three operationally important dimensions of sustainability (Ashford et al. 2012)

Business model innovation is key to the development of business models and modelling, in particular for sustainability. It is observed to align with the changing business environment. The next section will provide an overview of the potential business modelling frameworks that will highlight business model elements and potential business modelling designs to develop on for sustainability.

4 Business Modelling

Key authors who have articulated a business modelling process include Teece (2010), Osterwalder and Pigneur (2010), Richardson (2008) and Zott and Amit (2010) have contributed towards defining the elements of business model design (value proposition, creation, delivery and capture). Their focus has not been specifically on delivering sustainability, but they provide an extensive overview of the current state of the art and state of the practice. The Osterwalder and Pignuer (2010) canvas (below) and its elements, in particular, are seen to be a current dominant framework for practical use by industry. This section will present various existing business modelling frameworks and tools (in some cases) that yield useful insights into business modelling literature.

4.1 Business Model Canvas

Osterwalder and Pigneur's (2010) book 'Business Model Generation' offers a framework with tools such as the 'canvas' for working through business model conceptualisation and innovation. The book builds on their previous academic research, but introduces a highly visual element, emphasising the practical use of the tool by non-academics. The business model canvas (Fig. 4) seeks to develop a more generic framework with broad applicability across all industry sectors, utilising a standardised vocabulary and semantics. Their framework attempts to capture all the dominant components from the existing literature and is made up of nine building blocks. Their more recent iteration of the framework renames value configuration and capabilities to give business ontology of value proposition, customer segments, channels, customer relationships, key resources, key activities, key partnerships, cost structure and revenue streams. The framework places emphasis on defining concrete processes and operational activities, whereas other scholars seem to conceive the business model in rather more generic terms.

The business model canvas is seen to be a current dominant framework for practical use by industry. By combining most of the literature definitions, this

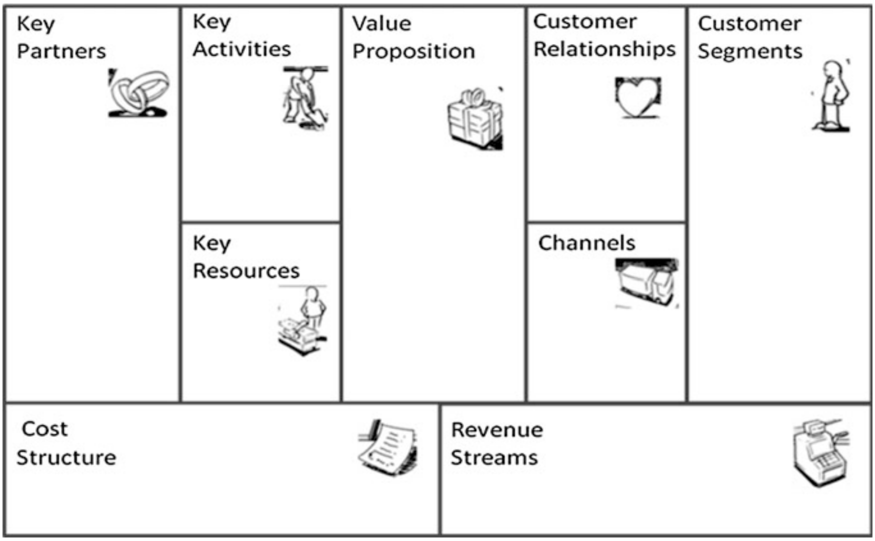

Fig. 4 Business model canvas and elements (Osterwalder and Pigneur 2010)

framework has achieved wide acceptance and is well received by industry. The nine elements of the canvas cover majority of the elements discussed in the business modelling literature. The canvas provides a good starting point for business model innovation to deliver sustainability. In theory, there is nothing to prevent the canvas being used to model a sustainable business model. However, the canvas is focused towards generating economic value and has limited stakeholder inclusion (limited to customers and immediate partners).

4.2 Business Model Framework

Richardson (2008) identifies ten different scholars' definitions, which collectively include 24 different elements. Research silos of interest have emerged in e-business, strategic issues, and innovation and technology management. Within these categories, orientations include transaction, revenue/profitability, product/technology, competition and activities/capabilities-based focuses (Zott et al. 2011). Richardson's framework (Table 1) suggests three main categories for business modelling with an emphasis on value.

4.3 Collaborative Networked Organisations (CNOs)

Romero and Molina's (2011) work on CNOs uses the business model concept to help describe the value proposition and systems for cocreation and delivery of the value proposition within a collaborative network. Their approach builds on Osterwalder and Pigneur's nine-building-block business model ontology, adapted to introduce the value cocreation system. The important characteristics they propose are as follows:

- Multivalue system perspective, encompassing different types of value—economic, social and knowledge,
- Multistakeholder approach, identifying each stakeholder's participation in the value creation process.

Table 1 Components of a business model framework (Richardson 2008)

Component	Description
Value proposition	What the firm will deliver to its customers, why they will be willing to pay for it and the firm's basic approach to competitive advantage
Value creation and delivery	How will the firm create and deliver that value for its customers and the source of competitive advantage
Value capture	How the firm generates revenue and profit

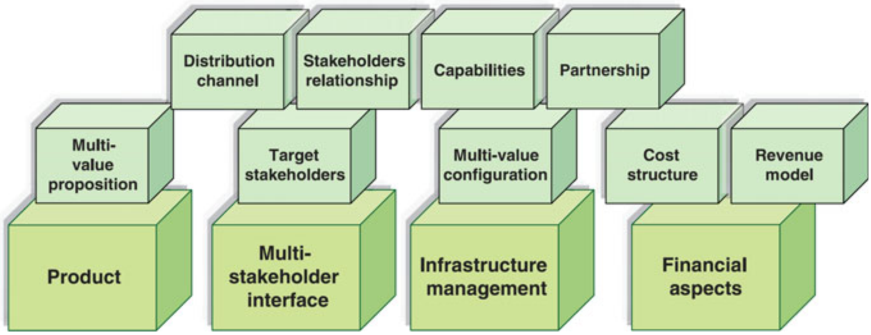

Fig. 5 Guidelines for CNO business model definition (Romero and Molina 2011)

Multistakeholder participation in value creation builds on the concepts of open innovation and open business models. Romero and Molina also discuss the role of the customer in actively engaging in the cocreation process to define the value proposition. Their approach has been developed in the ICT sector and does not explicitly target sustainability. However, the multivalue and multistakeholder perspectives seem directly applicable to the industrial sustainability challenges (Fig. 5).

4.4 *Business Model Design*

Teece (2010) proposes the following business model innovation process. The design (Fig. 6), however, emphasises on value proposition and mechanisms for value capture with an understanding of the stakeholders in the value chain, and the focus is primarily on customers. For a business modelling framework in order to encompass sustainability, it needs to have a wider group of stakeholders and understand what value is to the stakeholders (value proposition is not limited to customers) which will guide value creation, delivery and capture. The terminology used by Teece for a sustainable business model refers exclusively to long-term economic sustainability, although the process does not necessarily need to be limited in this way.

Chesbrough and Rosenbloom (2002) propose a comprehensive approach to business model conceptualisation that embodies strategy and financial modelling:

- Articulate the value proposition, i.e. the value created for users by the offering based on the technology,
- Identify a market segment, i.e. the users to whom the technology is useful and for what purpose, and specify the revenue generation mechanism(s) for the company,

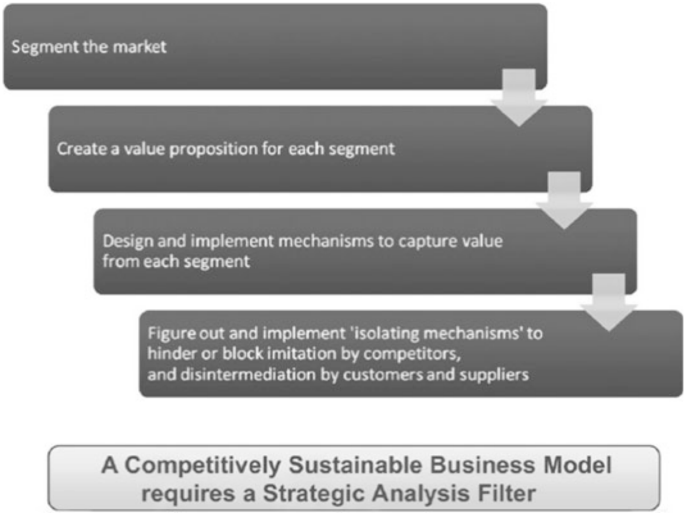

Fig. 6 Steps to achieve a sustainable business model (Teece 2010)

- Define the value chain of the company that is required to create and distribute the offering outlined in the value proposition,
- Determine the complementary assets needed to create the offering and support its position in the value chain,
- Position the firm within the value network context, including identification of potential complementors and competitors,
- Estimate the cost structure and profit potential of producing the offering, associating the business model concept to value creation,
- Formulate the competitive strategy by which the innovating company will gain and hold advantage over rivals and link the business model concept to strategy.

Chesbrough's work on open innovation in business model design is a potentially important addition to this subject area. 'Open business models enable an organization to be more effective in creating as well as capturing value. They help create value by leveraging many more ideas because of their inclusion of a variety of external concepts. They also allow greater value capture by utilizing a firm's key asset, resource or position not only in that organization's own operations but also in other companies' businesses' (Chesbrough and Appleyard 2007).

Zott and Amit (2010) propose an activity system perspective on business model design, combining the company-level focus with a broader understanding of how the company creates value through interactions throughout the value network. According to the authors, activity-based modelling builds on value creation mechanisms across boundaries of the company and industry, rather than adopting a firm-centric view of value creation. It attempts to conceptualise the interdependent activities connected by transactions within the broader networked context. The approach encourages a systems-thinking perspective, that is, a systemic and holistic

Table 2 Activity system design framework (Zott and Amit 2010)

Design elements	The architecture of an activity system
Content	What activities should be performed?
Structure	How should they be linked and sequenced?
Governance	Who should perform them and where?
Design themes	**The sources of the activity system's value creation**
Novelty	Adopt innovative content, structure or governance
Lock-in	Build in elements to retain business model stakeholders, e.g. customers
Complementarities	Bundle activities to generate more value
Efficiency	Reorganise activities to reduce transaction costs

approach to business model and industrial system design and development, rather than partial optimisation. Zott and Amit (2010) suggest two sets of parameters need to be considered—design elements and design themes (Table 2).

Magretta (2002) observes that a business model should answer questions such as—who is the customer? And what does the customer value? How do we make money in this business? What is the underlying economic logic that explains how we can deliver value to customers at an appropriate cost? To embed sustainability and the process of rethinking value and company logic in a business model, this thought needs to be extended to include environmental and social values with the inclusion of a broader range of stakeholders (value for each stakeholder) to understand their interactions in the value network.

5 Value

Normann and Ramirez (1993) observe that the understanding of value has changed due to 'global competition, changing markets and new technologies, opening new ways of creating value'. The literature observes two components of value 'perceived use value and exchange value', where perceived use value has a customer focus and is based on their perception of the product or service's use and exchange value is the amount paid for the product by the buyer to the producer (Bowman and Ambrosini 2000). Allee's (2000) value exchange illustrates (Fig. 7) an initial view of the exchanges, which are identified as—goods, services, revenues, knowledge and intangible value.

Sustainability, however, is often perceived from a limited value creation view, with considerably more focus from an economic, compliance, regulation or legislation perspective, hence raising the need for a more holistic view of sustainable value that integrates social and environmental goals. As Porter and Kramer (2011) suggest, 'businesses have rarely approached societal issues from a value perspective but have treated them as peripheral matters. This has obscured the connections between economic and social concerns'. From a network perspective, the scope of value needs to go beyond the two stakeholders primarily emphasised in the business

Fig. 7 Mapping the value exchange (Allee 2000)

model literature—customers, immediate partners and shareholders—and in a much more explicit manner that involves relationships, exchanges and interactions. Hence, value is defined as the set of benefits derived by a stakeholder from an exchange, taking into consideration the need for better/improved understanding of stakeholder value and seek opportunities for alignment and exchanges between stakeholders.

5.1 *Sustainable Value*

At the core of the business model is the concept of generating value. The literature (Chesbrough and Rosenbloom 2002; Richardson 2008; Zott and Amit 2010) introduces the terminology of the 'value proposition' to describe the product/service offering that the company makes to its customers and other stakeholders for which it receives payment and aims to return a profit. Porter and Kramer (2011) discuss the concept of 'shared value' and define it 'as policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates'. The authors suggest emphasis 'on identifying and expanding the connections between societal and economic progress' for value creation. Business models are usually perceived from a value creation perspective that focuses on satisfying the customer needs, economic return, compliance, regulation or legislation requirements. For sustainability, this focus is too narrow and raises the need for a more holistic view of value that integrates social and environmental goals towards addressing the impact of consumption and consumer behaviour, climate change, resource limitations, economic stability and growing public pressure for socially responsible business.

Sustainable value is defined as the well-being, improvement, continuity and preservation of the individual (human life), company, society and environment, in such a way that it satisfies the needs of the present without compromising intergenerational equity. It is conceived as 'environmental' sustainability which covers sustainable use of natural resources, biodiversity conservation, recycling of waste and pollution, and provision of additional ecological services such as climate regulation, pollination and enhancing soil fertility; 'social' sustainability is concerned with issues such as stakeholder participation, responsibility, labour standards, human rights, community relations, welfare, culture, poverty alleviation and equality; 'economic' is concerned with traditional measures of financial profitability, risk management and long-term economic viability or continuity of the company.

6 Value Network and Stakeholders

'A value network generates economic value through complex dynamic exchanges between one or more enterprises, customers, suppliers, strategic partners and the community. These networks engage in more than just transactions around goods, services, and revenue' (Allee 2000). This view of network could potentially be extended to include environmental and social value, thus underpinning sustainability into a network perspective. Traditionally, the value chain was defined and classified by Porter 'as a collection of activities that are performed to design, produce, market, deliver and support its product' (Porter 1985). The concept of value chain gained prominence through Porter's work (Kaplinsky 2000) and now has gone through modifications. The key difference between value networks and the study of value chains and supply chains is the recognition that value can be both financial and non-financial or intangible. Chapter "Towards Sustainability Governance in Value Networks" discusses a collaborative approach towards manufacturing networks. All business relationships include not only formal contractual activities, but also informal exchanges of information and benefits. Greater visibility of all the value flows within a network potentially provides insights for innovation and improvement.

As mentioned earlier, a holistic view of the value proposition requires active consideration of all stakeholders in the value network, who are influenced or influence directly and indirectly the activities of the company. The idea of companies having stakeholders became a 'commonplace in the management literature, both academic and professional' (Donaldson and Preston 1995). Freeman defines stakeholder of a company as 'any group or individual who can affect or is affected by the achievement of the organisation's objectives' (Freeman 1984). Freeman's stakeholder definition provides premise to explore stakeholders and their participation. Clarkson's (1995) view integrates the thought that stakeholders are not only shareholders but also a wider group and is not just focused on generating economic value. Clarkson (1995) further observes that 'the economic and social purpose of the corporation is to create and distribute increased wealth and value to all its primary stakeholder groups, without favouring one group at the expense of others'. However, their definition and explanation tend to be limited to stakeholders who are of primary importance and relevance to the business. For sustainability and in particular sustainable business modelling, this view of stakeholders needs to be expanded to include multiple stakeholders and to better understand opportunities for positive value exchange, while also eliminating negative value exchanges.

The key stakeholders, discussed frequently in relation to sustainability, include suppliers and partners, society, environment, suppliers, customers, investors and shareholders, governments, international organisations, non-government organisations (international and local) and the media. All business relationships include not only formal contractual activities, but also informal exchanges of information and benefits. Greater visibility of all the value flows within a network potentially provides insights for innovation and improvement. Allee (2011) discusses the importance of tangible and intangible value flows in network. Understanding of intangible flows is important in understanding network relationships and identifying opportunities for further collaboration, including environmental and social aspects. Zott and Amit (2010) present the activity system perspective on business model design, combining the firm-level focus with a broader understanding of how the company creates value through interactions throughout the value network. However, there is a limited work in developing the connection between business model and value network. This connection seems critical given the interdependencies between stakeholders in the networks, towards addressing sustainability. From a value network perspective, the scope of value needs to involve relationships, exchanges and interactions between stakeholders in a much more explicit manner to address the sustainable value creation opportunities.

Stakeholder analysis emphasises on those whose participation in the company is imperative for the company to function. This tends to incline towards economic focus. Clarkson observes that ‘the measurement of corporate success has traditionally been limited to the satisfaction of and creation of wealth for only one stakeholder, the shareholder. It has been demonstrated that the pursuit of this single measure is self-defeating (Clarkson 1995) as it tends overlooks the other stakeholders’ importance and impact on the company. Nonetheless, stakeholders are rarely treated equally. A gap exists in understanding ways to better get companies to align stakeholder interests.

Goodpaster (1991) observes the ‘stakeholder paradox’ that the company’s (and managers) strategic orientation should only be towards generating economic value ‘can be avoided by a more thoughtful understanding’ between stakeholders and company. Furthermore, it could be helpful to make a distinction between publicly traded companies and others when discussing/addressing stakeholders and shareholders. There is an ongoing debate over the role of the company in society and the company’s obligations towards social and environmental justices. One school of thought argues the company should seek to maximise economic profits, which in turn creates jobs and trickles down, and it is the role of government to deliver social programs, take care of the environment and redistribute wealth through taxation and spending. The opposing position, as advocated by civil society groups and labour movements, is that companies in exchange for limited liability and public infrastructure support have an implicit obligation to deliver social and environmental benefits. This is an important issue that requires a common position as it will dictate the types of business models, governance structures and policy interventions required.

7 Conclusions

The business model literature to date, though cognisant of shared value creation, demonstrates a principally customer-centric view of value. Few scholars discussed in the previous sections seem to probe the opportunities for value flows to a broader range of stakeholders. For sustainability, value-sharing exchanges with society and the natural environment need to become core considerations in business model development (Porter and Kramer 2011). Although the business model literature is conceptually driven, the review of frameworks and concepts in business modelling and value network provides a basis for sustainable business model and modelling development. Below is a summary of observations from this chapter:

- There is a difficulty in embedding sustainability into the business model elements—redefining business model elements with sustainability dimensions. Confusion and ambiguity in the definitions, use and boundary of the terms.
- The Osterwalder and Pigneur's (2010) business model canvas covers all elements discussed in the literature. Hence, it has been taken as a template to build on for a sustainable business model. New categories are to be added and removed.
- There is a minimal view of the full set of stakeholders in the value network and the interaction/link between them. Although the business model canvas covers all elements of a business model, the stakeholders are limited to customers, immediate partners and shareholders. Moreover, there is a limited understanding of how value might be perceived for the broader range of stakeholders and how that external value might be integrated within the business model.
- Tools that will assist in exploring other forms of value and analysing value exchanges will be important to drive and implement sustainability in companies.
  - The innovation literature focuses on how to create financial value from network relationships and does not necessarily consider other forms of value.
- Developing a business case for sustainability:
  - Premise to design business models and frameworks that will integrate and foster linkages between economic, social and environmental values.
- The inclusion of governance, corporate norms and values, and ownership structure to drive sustainability in the business model.

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Sustainable Business Models: Theoretical Reflections

Padmakshi Rana, Samuel W. Short, Steve Evans and Maria Holgado Granados

1 Introduction

Nidumolu et al. (2009) argue that sustainability is becoming increasingly essential for long-term success of companies. Those that do not rethink the business models around sustainability will limit long-term ability to create competitive advantage. Economic sustainability is a prerequisite for any viable business model, as without this there cannot be longevity for the business. While this is generally conceptualised as a requirement for growth and profitability, this need not necessarily be the case—there is a growing body of literature around the subjects of steady-state economics and not-for-profit social enterprises. Beyond economic sustainability, the need for environmental and social sustainability is increasingly recognised. Companies are attempting to address this within the framework of existing business models and exploring business model innovations.

Lüdeke-Freund (2010) defines a sustainable business model as 'a business model that creates competitive advantage through superior customer value and contributes to a sustainable development of the company and society can be interpreted as a sustainable business model'. The objective of a sustainable business model is the harmony of stakeholders' interests to ensure broader positive sustainable value creation, rather than compromises that benefit some stakeholder groups at the expense of others. As Bocken et al. (2014) assert, 'a sustainable business model aligns interests of all stakeholder groups and explicitly considers the environment and society as key stakeholders'. Sustainable business models seek to go beyond

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generating economic value primarily for customers and shareholders, but try to create social, environmental and economic value for a broader set of stakeholders in the industrial network. As such, a sustainable business model is the holistic value logic that encompasses economic, environmental and social goals while aligning the interests of all stakeholder groups.

2 Sustainable Business Modelling—Frameworks, Concepts and Tools

The aim is to create future sustainable business models that incorporate economic, environmental and social value in equal measure as an integral part of their business model. The existing work on sustainable business model and modelling is either at a theoretical/conceptual phase or informed through minimal industrial input. There are frameworks and case narratives which emphasise on sustainable business model for value creation and strategic elements of a business model. These are useful in developing an understanding of the area but tend to be limited to setting the research scope or have an environmental emphasis rather than a holistic view of the three metrics of sustainability—environmental, social and economic. The frameworks and concepts, below, provide input towards embedding sustainability in business models through the inclusion of broader range of stakeholders and assist towards redefining value to include environmental and social in addition to economic objectives, thus help towards a business case for sustainability.

2.1 Product-Service Systems

Product-service systems (PSS) and the more generic term 'servitisation' have received extensive consideration in the academic literature. Baines et al. (2007) present a literature review based on over 60 papers. Servitisation was coined by Vandermerwe's seminal paper, referring to the incremental addition of services to a product offering, generating a steady stream of service revenue in place of new product sales (Vandermerwe and Rada 1988). PSS is a specific case of servitisation.

Tukker and Tischner (2006), in particular, focus on PSS and the 3 pillars of sustainability (environmental, social and economic). They understand 'product service' as a specific type of 'offering' or 'value proposition' and the additional word 'system' containing a combination of the value network, technological architecture and revenue model, so the term 'product-service system' describes some parts of a business model. They study a way to generate this business model considering sustainability, and they offer a practical guideline to PSS development consisting of 5 steps (Fig. 1). They apply a sustainability approach during the whole process, but specifically in steps 2 and 3, they propose some tools that can be used to integrate sustainability during the development of the PSS, for example a system SWOT

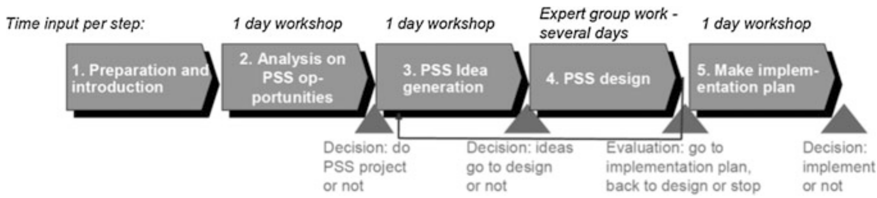

Fig. 1 Steps of the practical guideline to PSS development (Tukker and Tischner 2006)

analysis considering sustainability factors, sustainability guidelines to get inspiration for PSS idea development and a checklist for sustainability of ideas.

2.2 *Conceptualising Business Models for Sustainability*

Lüdeke-Freund (2009) emphasises on value creation, eco-innovation and strategic elements of a sustainable business model—value proposition, value creating logic and value delivery configuration. Lüdeke-Freund (2009) presents a preliminary framework (Fig. 2) that can be used for identifying, understanding and supporting sustainable business model and modelling processes and steps towards systematic research on business models and their contribution towards a business case for sustainability. It builds on the Osterwalder and Pigneur's (2010) business model canvas. The framework attempts to integrate broader social and environmental considerations within the value proposition and integrate eco-innovations into the value creation process.

Stubbs and Cocklin (2008) observe that 'the sustainable business model is not absolute or prescriptive. It will continually be enhanced as we gain further understanding of how companies operationalise sustainability'. Stubbs and Cocklin's case studies of sustainability, while limited to only two cases, provide some preliminary insights into some of the attributes of sustainable businesses. They propose a framework for analysis consisting of structural and cultural attributes. Their analysis serves a useful point for further consideration of how to build sustainable business models. They make a series of propositions on the important elements of a sustainable business model (Stubbs and Cocklin 2008):

- Draws on economic, environmental and social aspects of sustainability in defining an organisation's purpose,
- Uses an integral Triple Bottom Line approach in measuring performance,
- Considers needs of all stakeholders rather than giving priority to shareholder's expectations,
- Treats nature as a stakeholder and promotes environmental stewardship,
- Sustainability leaders/champions drive the necessary cultural and structural changes to implement sustainability and
- Encompasses systems-level perspective as well as the firm-level perspective.

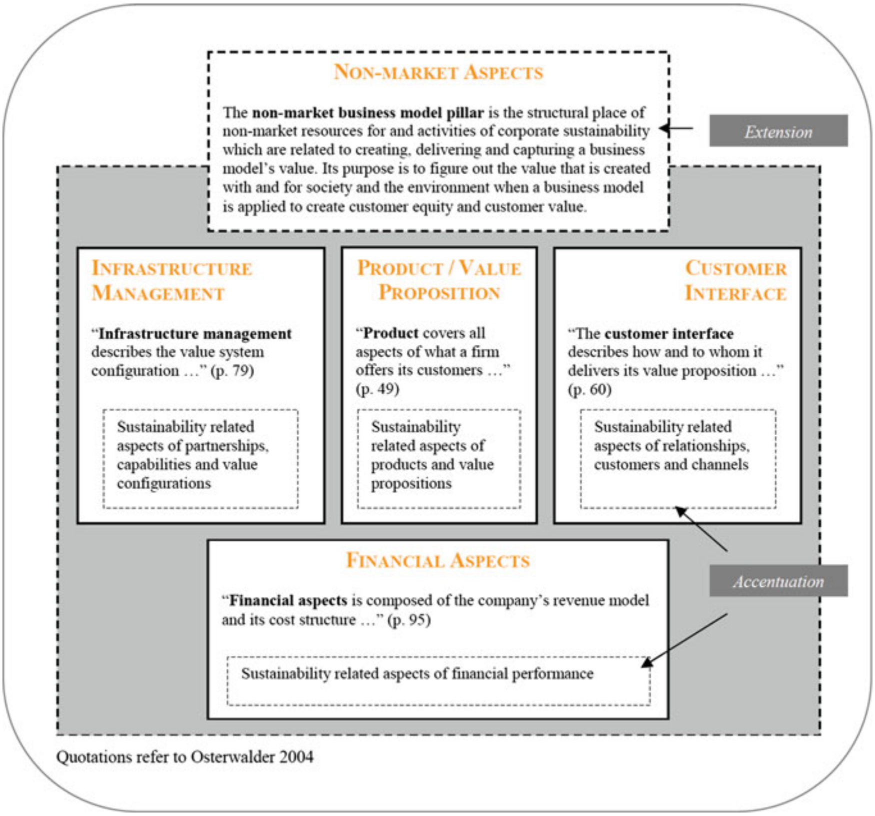

Fig. 2 Five-pillar template for business models for sustainability (Lüdeke-Freund 2009)

2.3 Business Case for Sustainability

Recognising that economic success is essential to any firm, the business case for sustainability is thus how to profit from increasing environmental and societal contributions, rather than simply incurring increased costs. As such, the drivers of a business case for sustainability are those that directly influence economic success and are similar to those of a conventional business case (Schaltegger et al. 2011, 2012):

- Costs and cost reduction;
- Sales and profit margin, including market entry or development, and competitive strategy;
- Risk and risk reduction;
- Reputation and brand value;
- Attractiveness as employer; and
- Innovative capabilities.

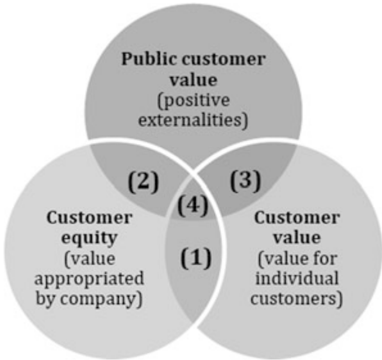

Fig. 3 Concept of extended customer value (Lüdeke-Freund 2010)

The link between voluntary sustainability activities and economic success may be different but as Schaltegger et al. (2011) suggest 'even voluntary social and environmental projects and activities can still be analysed in terms of their influence on these drivers'. A business case for sustainability provides the premise to design business models and frameworks that will integrate and foster linkages between economic, social and environmental value, with the assistance of change in corporate and business strategies.

Lüdeke-Freund (2010) in elaborating on the business case for sustainability observes that 'the central barrier to business cases with eco-innovations relates to the co-creation of private benefits for companies and customers and positive contributions to society and environment—i.e. public benefits'. Figure 3 illustrates co-creation of value through the concept of 'extended customer value or public customer value'.[1] For improving business and society relations and society's concern over corporate social responsibility, combining customer and public value is essential. Lüdeke-Freund emphasises on the following value creation areas to steer the direction of business model innovation for sustainability:

- Creating value for individual customers and the company,
- Creating value for the public and the company,
- Creating value for the public and individual customers,
- Creating value for the public, individual customers and the company.

2.4 Sustainable Business Model Archetypes

Business innovation approaches with a specific focus on sustainability are gaining increased attention. Business model element archetypes were initially defined as

[1]'To overcome the discrepancy between private and public benefits which occurs on imperfect markets, they must be co-created to generate threefold value: for the company, its customers and the public' (Lüdeke-Freund 2010).

common patterns within one element of the business model framework. The following preliminary archetypes were highlighted from literature as the ones that either align with sustainability or through innovation can guide sustainability thinking in the business model.

2.4.1 Internalising Externalities Archetypes

Goedkoop et al. (1999) initiated discussion on PSS in the sustainability literature with his proposition of the environmental benefits of PSS-based consumption. The suggested environmental benefits of PSS are as follows(Tukker and Tischner 2006):

- Decoupling of growth from material/energy throughput,
- Producer takes full life cycle responsibility encouraging environmental responsibility,
- Producer is incentivised to design for durability and upgradability and
- User has better awareness of full costs of usage and hence modifies behaviour.

Underpinning the proposed sustainability benefits of PSS is the potential to better internalise the environmental and social externalities associated with product manufacture, ownership and use. In so doing, this has the potential to initiate beneficial behavioural change in both producers and consumers towards a more sustainable society. PSS is already a well-established concept, particularly in the USA. There are many examples in the industrial B2B sector, and they appear to be emerging opportunities for growth in consumer B2C markets. One of the most well-known examples of this business model is the Xerox photocopying model, whereby the customer pays for a ‘document management solution’, leaving responsibility for selection and provision of the hardware, provision of toner and maintenance entirely in the hands of Xerox. Rolls Royce Aerospace, no longer sells aircraft engines, but instead offers engines on a ‘power-by-the-hour’ basis.

2.4.2 Network-Based Archetypes

This includes examples such as fair trade, resource stewardship, demand-side management and localisation. Fair trade and similar types of supplier accreditation programmes that drive more ethical or sustainable business practices at the grass roots level in developing nations have been in operation for almost two decades. These supply chain-focused initiatives aim at delivering environmental and social sustainability benefits funded through a differentiated product offering that delivers intangible value for consumers. Other similar certification initiatives focusing primarily on natural resources protection have been established. The most prominent include the Forest Stewardship Council (FSC) and the Marine Stewardship Council (MSC). These two initiatives aim to ensure that resources taken from nature are fully replenished through careful management of the extraction rate and regeneration programmes.

Demand-side management aims to address sustainability from the perspective of sustainable consumption. The business model emerged in the household energy sector, whereby utility providers are incentivized through government/taxpayer subsidies to assist consumers in reducing their energy consumption. Localisation is the focus on creating industry and jobs in domestic markets, perhaps closer to resource inputs, usually closer to end customers, perhaps offering a more customised local product/service offering, and with a closer connection to local communities. Localisation's primary contribution to sustainability is in the creation and sustaining of jobs and hence social sustainability, although may also offer environmental benefits.

An example of a framework that is based on whole systems thinking and recognises the need for understanding interactions, relationships and impacts between stakeholders and actors in the system and network is the Natural Step approach. The Natural Step approach is a 'five-level framework—systems, success, strategic, actions and tools' with tools such as the four system conditions (sustainability principles based on physical resource use and availability and 'people's capacity to meet basic human needs'), funnel ('metaphor to visualise social, economic and environmental pressures on a growing society') backcasting and life cycle assessment (Waldron et al. 2008).

2.4.3 Society-Based Archetypes

A complimentary literature stream is that of social enterprises. A social enterprise is defined as in between not-for-profit organisations and profit-maximising businesses. It has to cover its costs and repay capital, but is more social value than profit driven. This form of business has the ability to survive as a commercial entity, while also acting as a force for good. Yunus et al. (2010) propose the following transition from a traditional business model for considering a social business model and highlight the components of both model types (Fig. 4).

Thompson and MacMillan (2010) emphasise the challenges in managing trade-offs between competing objectives of social wealth creation and profit

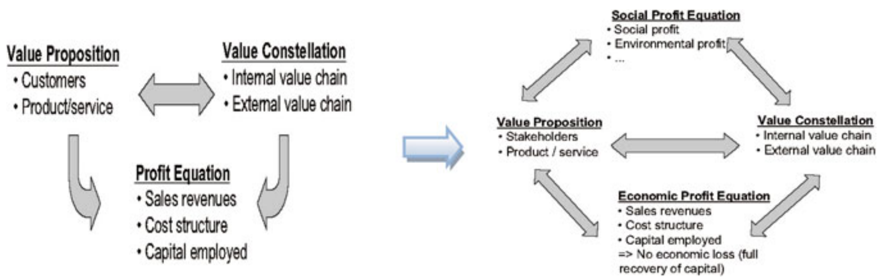

Fig. 4 Traditional business model to a social business model (Yunus et al. 2010)

generation. Grassl (2012) states that business models for social enterprises must fulfil the following conditions as a minimum:

- Drive by a social mission (i.e. abstain from distributing profit to shareholders),
- Generate positive externalities (spill overs) for society,
- Recognise the centrality of the entrepreneurial function and
- Achieve competitiveness on markets through effective planning and management.

2.4.4 Life Cycle-Based Archetypes

This category focuses on product and process redesign towards improving resource efficiency and reducing waste and pollution. It covers a range of concepts, often broadly referred to in the literature as eco-innovations. The two most prominent ones are industrial symbiosis demonstrating process innovation and cradle to cradle demonstrating a product focus. Other examples include biomimicry which is the science and art of emulating Nature's best biological ideas to solve human problems (Benyus 1997). These concepts are not mutually exclusive though, and progressive firms might combine such concepts within one business model.

Industrial symbiosis can be conceived as a value network concept, engaging traditionally separate industries in a relationship such that waste streams or by-products of one industry become feedstock for a second industry. Ideally firms would be co-located within industrial parks or zones to minimise transportation costs and loses. The theory is that this optimises material flows and reduces overall waste and pollution. Prerequisites are a systems-based view, mutual collaboration between firms and ideally geographical proximity. As a concept, it builds on what is known in Nature as mutualism, and the end result of the collaboration should of course be greater than if the entities operated independently. The application of industrial symbiosis is relatively infrequent, probably because it presents numerous business and policy challenges that inhibit widespread adoption. Symbiosis and development of planned eco-industrial parks have received renewed interest in the literature as environmental concerns have grown (Chertow 2000). Kalundborg in Denmark is a well-known example of industrial symbiosis. Taxonomy of 5 types of industrial symbiosis includes (Chertow 2000):

- Through waste exchanges—simple recycling, scrap dealers, etc.,
- Within an organisation or firm or facility,
- Among collocated firms in an eco-industrial park,
- Among local firms not collocated and
- Among firms organised across a broader region (virtually).

Cradle to cradle (McDonough and Braungart 2002) is used to describe a life cycle-based approach to product, process and system design, viewing the product as made up of organic and technical nutrients and seeking to create closed-loop material systems that recycle the materials, avoiding waste and avoiding toxins and pollutants. It is focused on material and eco-efficiency improvements. It can be seen as a potential business model, or least a core element of a business model as it can represent radical innovation in the value proposition and value creation activities of the company.

To further develop business modelling for sustainability, an approach (Short et al. 2012) using business model element archetypes was proposed to assist in business model innovation for sustainability. The above archetypes provided input to the initial categorisation of the approach. The archetypes (Table 1) attempt to capture the core mechanisms seen in practice and in the literature for delivering sustainability and offer a practical framework to facilitate innovation. The approach is grounded in real-world experience for sustainability, so it is anticipated that such an approach might reduce some of the uncertainty and risk currently associated with business model innovation for sustainability. This might also encourage broader experimentation and adoption of sustainability solutions.

Table 1 Sustainable business model element archetypes (Short et al. 2012)

Sustainable business model element archetype	Examples from literature and practice review
1. Maximise material and energy efficiency	
Do more with less resources, generating less waste, emissions and pollution	Biomimicry, dematerialisation (products and packaging), green chemistry, increased product functionality (to reduce number of products required), lean manufacturing, low-carbon solutions, slow manufacturing
2. Create value from 'waste'	
Turn waste streams, emissions and discarded products into feedstocks for other products and processes, and make best use of underutilised capacity	Circular economy, closed-loop production, cradle to cradle, extended producer responsibility, industrial symbiosis, recycling, remanufacturing, reuse, sharing assets (collaborative consumption), take-back management, use excess capacity
3. Deliver functionality, rather than ownership	
Provide services that satisfy users' needs without having to own physical products	Product-orientated PSS—maintenance and extended warranty, use-orientated PSS—rental, lease, shared, result-orientated PSS—pay per use, PFI (private finance initiative)/DBFO (design, build, finance, operate), CMS (chemical management services)
4. Encourage sufficiency	
Solutions that actively seek to reduce consumption and production	Consumer/user education (educational models—communication and awareness), demand management (including cap and trade), frugal business, premium branding (limited availability), product longevity, responsible product distribution/promotion, slow fashion

(continued)

Table 1 (continued)

Sustainable business model element archetype	Examples from literature and practice review
5. Adopt a stewardship role	
Proactively engaging with all stakeholders to ensure their long-term health and well-being	Biodiversity protection, consumer care—promote consumer health and well-being, choice-editing by retailers, ethical trade (fair trade), radical transparency, resource stewardship
6. Repurpose the business for society/environment	
Focusing the business on delivering social and environmental benefits, rather than economic profit maximisation	Base of pyramid solutions, biodiversity regeneration, entrepreneur/business support models, hybrid businesses, not-for-profit, social enterprise (for profit), social regeneration initiatives
7. Integrate business with other stakeholders	
Integrating business into local communities through inclusive collaborative approaches to business	Alternative ownership structures—collectives, partnerships, cooperatives, employee ownership, home-based working, localisation
8. Develop scale-up solutions	
Delivering sustainable solutions at a large scale to maximise benefits for society and the environment	Crowd-sourcing, collaborative approaches (sourcing, production, stakeholders), licensing, franchising, open-innovation
9. Radical innovation	
(Introduce system change through introduction of radical new technologies to facilitate a greener economy)	Lobbying/collaborating to change underlying principles of doing business. Step-change technology solutions—including renewable energy solutions, radical changes in product functionality

The archetypes were tested and refined in workshops and through further review of the literature and practice examples to identify business model innovations for sustainability. The title was changed from sustainable business model element archetypes to sustainable business model archetypes to reflect overall business model-level innovation and associate each archetype with the business model elements—value proposition, creation, delivery and capture. In-depth description on the individual categorisation of the final sustainable business model archetypes can be found in the Bocken et al. 2014 paper on *A literature and practice review to identify Sustainable Business Model Archetypes* in the Journal of Cleaner Production. The archetypes are included in the toolset explained in Chap. "Toolset for Sustainable Business Modelling" to help manufacturing companies innovate and develop sustainable business models.

Tools such as value network analysis (Allee 2011), value tree analysis, scenario analysis and system map and shared value innovation and creation tools such as blue ocean strategy (Kim and Mauborgne 2005) and value framework (Den Ouden 2012) contributed towards design and development of tools for sustainability.

3 Discussion

The frameworks, concepts and tools explained (see Sect. 4 in Chap. "Business Models and Business Modelling: State of Art" and Sect. 2 above) have contributed significantly towards business modelling for sustainable manufacturing networks that focus on generating network perspective to develop and transform the sustainable value proposition. Each of them provides guidance and insights on the design and elements of a process and tools/methods. In particular, three processes given their proximity to embedding sustainability in a business modelling and academic and industrial popularity were considered.

The Tukker and Tischner (2006) process (see Sect. 2 above) on designing and developing PSS solutions with a focus on eco-efficiency and competitiveness presents three phases—'analysing, creating and defining new ideas and realising the detailed concept' together with the 'innovation scan' process (Tukker and Van Halen 2003) on added value creation through PSS, provide insight on phases and steps for business modelling. They consider a combination of idea generation, planning, mapping and eco-design tools some of which are created specifically to fulfil sustainability requirements such as modified System SWOT (strengths, weaknesses and opportunities and threats) analysis—integrating sustainability into the SWOT analysis. Other tools such as the system map—an approach to visualise business ideas focusing on PSS, scenario writing, life cycle assessment and stakeholder motivation matrix—are based on systems and life cycle perspective. Teece's (2010) work on the business modelling steps (segment the market, create a value proposition for each segment, design and implement mechanism to capture value from each segment—Sect. 4 in Chap. "Business Models and Business Modelling: State of Art") explored for business model design is helpful in providing the foundation and input into the design process of business models and focuses on the need to integrate the wider business environment (Teece 2010). The Osterwalder and Pigneur (2010) process and toolset provide a comprehensive design process (mobilise—setting the stage, understand—immersion, design—inquiry and implement (execution) and manage), which is grounded in academic literature, includes a set of proven tools and methods such as the visually compelling business model canvas and manual, SWOT and scenario planning, proven with practitioners, and uses practical examples.

However, the Tukker and Tischner (2006) process particularly focuses on PSS and is limited in providing a more general approach to sustainable business modelling. PSS is only one aspect of sustainability, and it cannot be effective in isolation and hence needs to be combined more comprehensively with other sustainability initiatives. Moreover, not only must the solution (PSS) for stakeholders be sustainable but also the way it is sourced, produced, used and recycled. The different methods to realise sustainability will be illustrated with the help of the prospective development framework in Chap. "Methods and tools for Sustainable development of products and services" a part of which builds on the PSS approach and some of its tools. Teece and Osterwalder and Pigneur processes are primarily focused on delivering economic value with a particular focus on two stakeholders—customers and shareholders. Moreover, the focus of Teece's business model design work is primarily on 'how to deliver what the customer wants in a cost-effective and timely fashion' (Teece 2010). The author further highlights limited research in the business model design area. The Osterwalder and Pigneur process does not necessarily include a specific focus on sustainability. The emphasis is exclusively on the value proposition for the customer with limited consideration of broader network perspectives on business model design, and examples provided in the guide are limited and do not illustrate sustainability concepts. They suggest sustainability might be considered by undertaking the business model innovation process three times—optimising for each sustainability dimension—and then combining the outcomes.

In the specific context of sustainable business modelling, Lüdeke-Freund's (2009, 2010) work integrates broader social and environmental considerations within the value proposition and incorporates eco-innovations into the value creation process. It can be used for identifying, understanding and supporting sustainable business model and modelling process and contribution towards a business case for sustainability. The author further introduces the non-market aspects pillar and the idea of creating public value. Stubbs and Cocklin (2008) emphasise structural and cultural attributes in describing the BM. Schaltegger et al. (2012) work on business case for sustainability provides the premise to design business models and frameworks that will integrate and foster linkages between economic, social and environmental value, with the assistance of change in corporate and business strategies. Romero and Molina (2011) introduce multi-value, multi-stakeholder perspectives. However, these frameworks focus on environmental value, with limited or no consideration for social aspects and limited grounding in practice. Nonetheless, they highlight key elements such as stakeholders and value creation, which potentially assist in the development of a sustainable business model.

The processes, frameworks and tools proposed by these leading authors all have merit and provide sound basis for sustainable business modelling. Nonetheless, an enhanced and simplified process and set of tools that better integrates the business model concept with sustainability focused on delivering sustainable value is considered necessary.

4 Conclusions

The interconnected nature of the world with multiple stakeholder networks and interrelationships between different industries through product use and disposal phase requires a long-term vision and holistic solution for redesigning business models to co-create multi-stakeholder and sustainable value. As Krantz (2010) proposes, 'companies will need even bigger changes, including new business models, greater trust and greater stakeholder engagement' based on a 'long-term vision' for pursuing sustainability. Although environmental and social approaches have been developed and implemented by companies it is often through compliance with regulations or incremental environmental and social initiatives (eco-efficiency, eco-innovation and add-on corporate social responsibility activities in the community). While important, these approaches have not generally embedded sustainability into the core of a business and become part of a supplement to a business, or simply a coincidence. This change requires a significant shift in the way businesses are conceived and operated. Business model innovation that embeds sustainability in the proposition, creation, delivery and capture of value through a multi-stakeholder view is necessary. The following key gaps were considered in the development of the sustainable business modelling process and tools:

- Business model innovation and design for sustainability are generally ad hoc, incremental, relying on radical visionary leadership, and rarely seem to follow a prescribed process. As such, they are often experimental which potentially introduces risk and slows the rate of general adoption;
- Developing a business case for sustainability is important;
- Need for network centric business model design to ensure consideration of network-wide perspective rather than a firm-centric view;
- There is limited view on the set of stakeholders, their goals and value and the interaction/link between stakeholders in the value network; and
- Existing business model thinking and design limited to economic value, customers, shareholders and investors.
- There is a lack of process and tools that can be used by companies to evaluate novel business models. More particularly, tools and methods explore other forms of value and for analysing exchanges and relationships, while looking systematically for opportunities for broader forms of value creation through the extended industrial network. For example, searching for partner companies/organisations outside traditional value chain of the company in order to deliver sustainability is as follows:
  – Rethinking the business purpose—sustainability into the core of the business operations,
  – Taking a longer term perspective on value rather than short-term gain and
  – Broader range of stakeholders including environment and society is required.
- Companies may not be fully aware of the full range of value outcomes of their business operations:
  – Value for a network of stakeholders—aligning conflicts/frictions, various forms of value.

Chapters "Business Models and Business Modelling: State of Art" and "Sustainable Business Models: Theoretical Reflections" are supplemented by five case studies, which are presented in the following chapter. They provided industrial input towards understanding business modelling, particularly from a sustainability perspective.

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Practice Review of Business Models for Sustainability

Padmakshi Rana, Samuel W. Short and Steve Evans

1 Introduction

It was observed through literature that business model innovation is a key to business success (Chesbrough 2010, Lüdeke-Freund 2010 and Amit and Zott 2012). Likewise for embedding sustainability into businesses, authors such as Stubbs and Cocklin (2008), Lüdeke-Freund (2010), Schaltegger et al. (2011, 2012) and Porter and Kramer (2011) consider business model innovation and redesign to be essential in generating real (long-term, multidimensional) sustainable value. Key authors who have articulated a business modelling process include Teece (2010), Osterwalder and Pigneur (2005, 2010) and authors such as Richardson (2008) and Zott and Amit (2010) have contributed towards defining the elements of business model design (value proposition, creation, delivery and capture). Their focus has not been specifically on delivering sustainability, but they provide an extensive overview of the current state of the art and state of practice. Tukker and Tischner (2006), Baines et al. (2007), Stubbs and Cocklin (2008), Lüdeke-Freund (2010), and Anderson and White (2011) have contributed to academic and industrial research on sustainable business models and modelling. However, there is still a requirement for frameworks/processes and tools that support companies in thinking about and embedding sustainability into their business logic, everyday operations and exploring other forms of value (social and environmental) and analysing value exchanges (stakeholders). To support this understanding and analysis from literature, an empirical study was conducted.

This chapter elaborates on the five cases investigated to explore the current industrial practice in sustainability, business models and modelling, business model

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innovation and stakeholders. The cases include Riversimple and CLAAS from the SustainValue project consortium and four other external companies. For confidentiality purpose, the names of the external companies and the interviewees at the six companies have not been revealed. The interviews were conducted based on semi-structured questionnaire. A brief overview of the cases is provided. This is followed by an overall summary of findings and gaps, focusing on the company perspective on sustainability, business model and modelling, business model innovation and stakeholders in the value network.

2 Overview of the Cases

Desai (2002) suggests that 'business and industry, as both producer and consumer of goods and services, affects economic and social development, resource consumption and the environment in a direct way'. A sustainable society and the associated sustainable manufacturing network is conceived as one that permits 'pursuing individual and societal well-being' without undermining the natural environment and without compromising inter-generational equity. 'Sustainability issues in manufacturing and production are growing exponentially. Initially referring to environmental considerations, sustainability now also encompasses social and economical responsibilities' (Burke and Gaughran 2007). The five cases below were selected given their use and implementation of sustainability initiatives and business modelling activities.

Company A

Company A is a wholly owned subsidiary of a large multinational firm. It is expanding into new areas of operations with a diverse portfolio of various product segments. Company A is one of the leading global sugar producers in the world and is also a major producer of biomass, processed to produce sugar, ethanol, furfural and many other products. It has operations in number of countries.

The Company has a decentralised approach to management and sustainability with a traditional governance structure. There is some coordination involvement at the Company level, but it primarily operates on a localised approach, so each factory can respond to local requirements and conditions. It has priority areas for sustainability, which include energy, supply chain standards, water, poverty alleviation, agricultural productivity and biodiversity. In addition, health and safety, governance and ethics are observed. The firm's approach to sustainability is embedding the priority areas into the business decisions, strategy and processes/operations. The activities that take place under each priority have business reasons, to which sustainability is aligned. The business KPI's (key performance indicators) includes sustainability objectives. They use stakeholder mapping to understand their relationships and interactions with the partners. The firm has synergies between their departments and other group firms.

Company A's sustainability initiatives have been partly driven by necessity; for example, cane sugar production does not need external energy input because the cane has traditionally been burnt to generate energy. As such, there was no traditional focus on saving energy. However, changing the perspective—now excess cane is sold for paper incentivising them to minimise energy use. The industry as a whole is going towards co-generation, and adding greater value. They, now, consider their waste streams as co-product streams. Furthermore, industrial symbiosis (see Chap. "State of the Art Regarding Existing Approaches") as they have developed, is dependent on having a critical mass of co-products (waste streams) to support the investment in secondary processing plants. Company A provides a comprehensive example of single firm industrial symbiosis model that integrates sustainability—within a firm or facility, combining the production of sugar with co-products.

Notable issues for business model and modelling:

- Company A primarily applies an economic logic to sustainability
- Size and scale of the firm is important for industrial symbiosis
- Culture and mindset at Company A had an impact on the desire to an innovator
- It is important to ensure that value is shared in the supply chain and the farmers are profitable—building a sustainable industry in partnership
- For firms, particularly resource-stretched small companies, there needs a simple tool to help prioritise what is most important for the business
- The challenges in climate change and population growth/demographic change in terms of—regulation, reputation and cost (of input)

Company B—Riversimple

The company is at an early start-up phase and was conceived to provide a personal and environmentally sustainable mobility solution (car) encompassing technology solution and full service provision, adopting a total systems perspective. Riversimple is based on a sale of service business model (PSS solution), which is about moving from resource consumption to resource efficiency. Current sales-based model rewards selling more and hence rewards the company directly for resource use; by shifting to a sale of service model, the company retains ownership and responsibility of the vehicle and its operating costs for the product life and so is incentivised to design and build for durability, longevity, and efficiency in use, and end-of-life solutions. The company has an innovative governance model, where the company's stakeholder board elects the board of directors and executives. The stewards' board oversees the board of directors, and the custodian body represents the owners in limited partnership structure. This model is considered to assist in enhancing interactions and collaboration between stakeholders, to deliver sustainable value (environmental, social and economic), by ensuring that financial interests are balanced with the interests of the other stakeholders.

Sustainable business modelling for the company has been ad hoc (influences from The Natural Step framework) and driven by visionary leadership. The breakthrough in the motor industry, according to the founder, will come in the way a car is put together, the business model and delivery system (systems integration). It can be very powerful, particularly where there is a disruptive technology. The founder believes that for car sector innovation, the barriers are not really technological, but business and politics. Furthermore, the innovation is not in the individual components, but comes out of the synergy between the elements of the car (carbon fibre, fuel cells, ultra-capacitors and electric motors). However, with respect to the PSS solution there are significant questions around consumer adoption and ownership and how this might hinder the business model. The role of fashion and status and financial investment needs further understanding as these may represent significant barriers. The aim of the business model and governance model was to better align the corporate interests with that of the consumer and the environment, but it is still somewhat hard to see how one avoids corporate demands for stimulating market growth and stimulating driving miles. Further clarification of the governance/ownership model is required.

Notable issues for business model and modelling:

- Investor being an integral stakeholder of the business model for funds and commercialisation. The current corporate approach to sustainability largely relies on altruism, which is not a strong base.
- Investor resistance to the model/structure needs further investigation and may provide insights into barriers/keys to sustainability—how other firms might go about introducing sustainability while avoiding some of the pitfalls.
- The existing business models do not accommodate the innovation at Company B, who potentially have a sustainable business modelling process that integrates a broader range of stakeholders, redefines value to include environmental and social considerations with a novel governance model.
- Importance on governance and policy implications.
- The focus is on the performance of the whole system.
- The role of branding/positioning in successful implementation of sustainability initiatives.
- A larger social issue is the effect of a transition of ownership from the general consumer to corporate interests, given that ownership is often related to control

Company C

Company C is a technical ceramics company, in medical and dental, copiers and printers, and kitchenware, with 60,000 employees and worldwide operations. It has a decentralised ‘amoeba’ management structure autonomously. The Company is the UK sales and marketing subsidiary.

Sustainability has been rooted in the foundation of the business since start-up—although not specifically termed sustainability. Their approach significantly predates the concept. The founder is highly regarded and has funded several business schools that teach their ‘business philosophy’. The Company’s approach is either to try to introduce environmentally preferably solutions to an existing technology, or to develop technologies that are intrinsically environmental and socially responsible. Company C’s competitors use highly complex toner cartridges to perpetuate razor-blades business model.

Their model forces them to make highly complex/wasteful/intrinsically unsustainable products—estimate 47-m print cartridges go to landfill every year. Company C has deliberately gone down a path that is viewed as more sustainable.

Company C's new product was launched in the early 1990s as a 'green' solution. At the time, green was not on the agenda, so switched marketing to talk about total cost of ownership—typical saving 2/3 based on simplified and cheaper consumables. In 2001, green interest started to rise, so they established a green users' network that became fairly influential in driving opinion and awareness. In the last years, awareness has reached mainstream, so the need for such a network is much reduced now, and may be disbanded, having achieved its purpose.

The Company has no direct sales to customer's channel. It only sells through distributors, dealers and resellers. It has two distributors and about hundred resellers/dealers. Company C avoids the conflict between direct sales and channel distribution that occurs with some of their competitors.

Notable issues for business model and modelling:

- Social and environmental activities have not specifically been identified as sustainability, because they have all been embedded in the way they do business—mindset and behaviour
- Private sector is better than public sector at considering through life costs. The life duration that is considered is generally 5 years, which is up from 3 years—in part because the technology is more mature, so less likely to be rapidly obsolete
- The company is clearly driving a lot of the sustainability initiatives from within. Nonetheless, regulation and legislation helps them persuade customers to change and demand change. Government to provide clarity on regulation and legislation
- Education on sustainability initiatives—learning culture
- A strong culture drives the sustainability ethos of the business. How might organisations go about realigning culture with sustainability values—employee indoctrination, role of the education system and workplace initiatives?
- Engaging employees and customers about the company's values. Certain businesses are now starting to select their partners based on a values match, rather than products and technology

Company D

The Company is a shelving and storage manufacturer and supplier. It was founded in the late 1950s as a radical design-driven company, introducing a modular and timeless design philosophy to product design. Its vision is to manufacture furniture to last as long as possible, be adaptable and infinitely reusable, and discreet (not subject to fashion trends). The company specifically avoids built-in obsolescence and eschews furniture fashion/trends. The key ingredient is trust, so that customer trusts that the company has their best interest in mind, the product will be around for a long time, they can extend/buy more as they need it, and the product is designed and manufactured for best possible service. The company's business reflects longevity, durability, modularity, interchangeability, closeness to customer and sacrificing growth for the business model through its products. The company focuses on encouraging sufficiency, reducing environmental (waste, material use, carbon emissions) and social (working conditions, recruitment standards aligned with the company's values) impacts while contributing towards improving the quality of life and facilitating sustainable consumption behaviour of consumers.

The Company's model offers an example for sustainable business modelling—sustainability is embedded throughout the business, where vision, value and organisational culture drive the initiatives on sustainable consumption and production. However, the scale is very small, so the impact on society is equally small and there is a need for novel investment model to raise funds that breaks the attachment with accumulation of money and consumption.

Company D has actively reduced intermediaries in the distribution chain. It focuses on preferred suppliers, which equally reduces the network size, although could increase the value exchange within the network. The Company sources locally for most components and materials, and all small businesses. It actively aims to 'infect' their suppliers with the Company D philosophy and works with the suppliers to introduce cost savings, waste reduction.

Notable issues for business model and modelling:

- Role of value/culture in driving sustainability
- Extending Company E model to other product categories. For example into the building industry sector for provision of sustainable homes—well-built, long-lasting, efficient, attractive, and good long-term support (systems thinking approach).
- Customer and Company committed to mutual benefit of each other—extended customer value or public customer value creation.
- Consistency in policy
- Ownership of the building to implement sustainability initiatives
- Tough and lengthy recruitment process based firstly on character and secondly on skills-understanding peoples' values takes time

Company E (CLASS)

CLAAS manufactures and supplies agricultural machines and systems. Their product range includes combines and harvesters; tractors; trailers; efficient agricultural systems—GPS steering, telematic operations optimisation and offers agricultural managements systems. As part of various research and development activities, CLAAS has developed new methods and architectures to improve agricultural value added. The Company is a wholly owned family business employing 9,000 employees, serving a global customer base. Headquartered in Germany, it has production facilities on 3 continents, and a global network of distributors. Major customer market segments in order of size are Western Europe, Eastern Europe (including Russia) and rest of the world (including USA, India and some businesses in Africa).

CLAAS is initiating sustainability projects, enabling extension of tools into new networks of machines and control systems, enterprise resource planning (ERP) systems and new business models for agriculture—improve efficiency of the hardware and the soil through better services. For example, better coordination of all machines in the harvesting process to improve use of the machinery improves fuel usage, minimising the harvesting time as it reduces risk of loss. Being wholly owned family business, the close link between the employees and the farming community is inherent to CLAAS.

The CLAAS model is about development, building and selling of machines through a dealership network. Follow-on sale of spare parts represents a second-revenue stream. There is an increasing focus on selling software systems, again offered as products. These are mainly sold with new products. Software retrofits are undertaken, but at present form only a small part of the business.

Change in customer structure will support development of new business models as farming is getting more and more professional. Farms are getting bigger, more professional and international. For example, a group of professional investors who partly own farms especially in Germany, the UK and France, use machines in a fleet in different regions and sometimes even countries. The farming processes are controlled by professional 'Agricultural-Managers' with a university degree. These types of farms are becoming more popular, especially after the political change in Eastern Europe. Simultaneously, the number of traditional small farms with engaged family workers is getting smaller or farming is done as a kind of 'hobby'—influence on business models.

Notable issues for business model and modelling:

- There is a natural focus on environmental issues due to the nature of the agricultural industry—caring for the soil, limiting pollution and resource efficiency
- Innovation is first and foremost driven by economic opportunities associated with satisfying customer needs for process efficiencies and productivity improvements
- Choice of better or less sustainable solutions is often dictated by the customers' demands and budgets. CLAAS and their customers are not end-consumer facing, so see relatively little pressure from their customers for 'green' performance
- Exploration of the family ownership and governance structure—how this influences sustainability initiatives and role of culture within the business—the close link between the employees and the farming community, which appears to be important for the business success
- Climate change adaptation strategies seem important for this sector and may radically change demands and regional requirement specifications. Agricultural domain will be affected either positively or negatively, in different regions
- Strong influence of subsidy/documentation policy of national/supranational institutions—agricultural domain faces a lot of documentation rules such as usage of pesticides or fertilizer

3 Findings from the Cases

The narratives from the industrial cases present and delineate current industrial practice in embedding sustainability into business models and the key areas of focus in rethinking about and developing a sustainable modelling process and tools. Tables 1 and 2 provide an overview of the key components explored during the empirical study and the findings.

There seems to be very few start-ups, SMEs and large firms, who are either already working or beginning to work towards the integration of sustainability into business models, modelling and business processes. The business modelling process is observed to typically be organic; corporate culture (norm and values) and governance model/structure of the firm impacts on the process and influences whether or not the business model successfully incorporates sustainability. If

Table 1 Case studies A, B, C

	A	B	C
Sustainability type	Norm	Extreme	Norm
Company size/maturity	MNC	Start-up	MNC
Position on sustainability continuum (Willard 2005)	Integrated strategy	Purpose/passion	Purpose/passion
Industry sector	Food and agriculture	Personal transportation	Printing and copying equipment
Ownership	Wholly owned subsidiary of publicly listed company. Majority shareholder is a charitable trust	Private ownership with angel financing	Wholly owned subsidiary of publicly listed company
Sustainability dimensions	Environmental and social	Environmental	Environmental
Key drivers for sustainability initiatives	Economic motive, climate change and resource limitations	Perceived need for environmentally friendly personal mobility solution	Economic motive, resource efficiency, customer demand for low cost of ownership
Business model	Life cycle—industrial symbiosis, Network-based—sustainable supply network (community based)	PSS (throughout value chain), cradle-to-cradle, network-based localisation of production, open-source design	Life cycle—cradle-to-cradle, increasingly PSS (add-on services), philanthropy

(continued)

Table 1 (continued)

	A	B	C
Business Model innovation processes employed	Focus on frugality–efficiency, waste reduction and reuse. Formal process for assessing sustainability dimensions of all new business initiatives. Stakeholder mapping used	Systematic innovation process, iterative redesign for optimisation. Current tools available are not considered particularly helpful	Little formal focus on business models or sustainability per se
Value network and stakeholders	Close relationship with growers in supply chain, and engagement with local communities around the growers. B2B, not retail consumer facing	Network of suppliers for technology, hydrogen infrastructure and local council partners for programme roll-out	Distributors and resellers. As a sales division have little influence over product/manufacturing decisions, employees recognised as key to the value network
Policy influences	Partially driven by environmental policy influence; social programmes largely driven by necessity in developing nations; policy encouraging attention on bio-fuels and bio-plastics	Looking far beyond current policy requirements. Current legislation acts as considerable barrier to development of the sector.	Positive impact of legislation (such as WEEE and energy star compliance). Further regulation would probably benefit their competitive position, but more importantly provide much needed clarity to the industry

considered, sustainability is seen more as a detached or isolated concept. Within the stakeholder discussion, the interactions and understanding value from each stakeholder's perspective is minimal given the dynamic and complex structure of value networks. Summary of gaps in practice is as follows:

- It is difficult to embed sustainability thinking into business modelling for companies.
- The thought and development of business models and sustainable business models and modelling is an organic process and requiring visionary leadership
- Individual context for every organisation impacts on whether a business model is more sustainable
- There is limited view on who the set of stakeholders are and the interaction/link between stakeholders—value network
- There is a lack of tools that can be used by companies to evaluate novel business models and value networks
- Governance, the role of corporate culture and the impact of external financing/shareholders are always relevant

Table 2 Case studies D, E

	D	E
Sustainability Type	Extreme	Norm
Company size/maturity	SME	MNC
Position on sustainability continuum (Willard 2005)	Purpose/Passion	Compliance
Industry sector	Home and Office Furniture	Food and Agriculture–Equipment
Ownership	100 % private ownership, run by owners	100 % private ownership. Run by family members
Sustainability dimensions	Environmental and Social	Environmental
Key drivers for sustainability initiatives	Resource efficiency, long-term view of value optimisation for the customer and the environment	Improving productivity and sustainability of agricultural land. Fuel and time efficiencies
Business model	Life cycle—cradle-to-cradle, extended value proposition, 80 % service business, product longevity (anti-fast fashion)	Conventional design–make–sell through distributors, considering PSS
Business model innovation processes employed	Limited formal development of business model for sustainability. An ad hoc process of business improvement	PSS represents a strategic add-on to the core product business. Various strategy tools employed to consider customer demands, pricing and distribution channels
Value network and stakeholders	Removed intermediaries from distribution network to ensure closeness to customers. Local manufacturing strategy. Employees seen as key to the business model. Looking to strengthen ties with customers and suppliers through financing structure. Also investigating potential for turning firm into employee owned	Suppliers provide major mechanical systems and software solutions. Some wholly owned distributors and network of other dealers and importers. Relationships with customers through employees, however, limited long-term customer relationships
Policy influences	Largely operating well beyond current legislative requirements. Not influenced by legislation, although highlight needs for improved legislation to help SME's, and needs for legislation to drive changes in attitude towards built-in obsolescence, product responsibility	Not discussed extensively. Largely passive position, as fuel efficiencies are dictated by engine suppliers, and not large enough customers to demand specific changes themselves.

- Governance—decision-making and investor influence—companies A, B, D and E.
- Corporate culture includes norms and values, incentives, selection process and ongoing training. This has been emphasised by companies A, B, D and E
- Further understanding of the business model might better inform policy decision-making process
- Greater emphasis might be placed on the ad hoc business model development approaches seen in practice, and the lack of any business model innovation tools being employed
- Design (product and processes) is important—company A, B and F (processes), companies B, D and E (product)
- Product–service system is often cited as a sustainable solution, but interesting that Company D does not operate this model themselves (some of their distributors do offer PSS), and there is a take-back programme in place (WEEE requirements)
- Common to all companies—closed-loop models

4 Conclusions

The review of findings from practice together with the observations from literature contributed towards clarity on the design process and supportive tools for sustainable business modelling that will provide companies with an integrated solution to develop transform and implement a new sustainable value proposition. The following chapter presents overview of the use and test stage and the working sustainable business modelling (SBM) process and toolset.

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Toolset for Sustainable Business Modelling

Padmakshi Rana, Samuel W. Short, Steve Evans, Maria Holgado Granados and Katri Valkokari

1 Introduction

A sustainable business modelling (SBM) process and toolset needs to—embed sustainability ethos and initiatives into the business purpose and value network activities, integrate a broader multistakeholder view on generating environmental, social and economic value, identify and develop collaborations between the stakeholders to eliminate negative environmental and social impacts, and be appropriate for use by companies and practitioners. Some specific additional tools that explicitly address sustainability are required, for a business modelling process that delivers sustainability, more particularly addresses the impact on the environment and society (resource availability, climate change, waste and workplace environment). The following requirements were established based on the observations and gaps discussed in Chaps. "Business Models and Modelling: State of Art", "Sustainable Business Models: Theoretical Reflections", and "Practice Review of Business Models for Sustainability", for designing and developing the SBM process and toolset:

- Provide guidance on establishing the fundamental purpose of the company and network.

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- Uses a system- and company-level approach for interventions and changes (configuration and coordination of value creation, delivery and capture).
- A comprehensive framework for investigation and understanding of the value proposition of the company and network for all stakeholders (analysis of existing business model). Specifically, the approach needs to be able to identify negative outcomes for society and the environment.
- Assist in transforming the sustainable value proposition:
  - Provide guidance on how the business model might be amended/extended to enhance sustainability, i.e. ways to align the interests of the environment and society with the consumers and investors' interests.
- Provide options on the specific design of the business model (what) in order to deliver sustainable solutions, while supporting change within the companies.

Likewise, tool selection criteria were established, specifically for selection and development of the toolset:

- *Time required* this includes the period required for using the tool, which involves willingness and availability of the user to spend time on it. It also involves the time required for data collection and analysis. Hence, it has been classified into—a few hours, in between and more than 1 week.
- *Skills and knowledge required* there are tools that require a higher level of external facilitation and support in its use and application compared to others. It is considered preferable to identify, adapt and design tools and methods that involve ease of use. Therefore, three levels were identified in this criterion—standard skills, general knowledge and no specific need for field expertise, in between and highly specialised skills, multidisciplinary knowledge and field expertise. These consider the difficulty of implementing the tool (i.e. mathematical or statistical competence) and the depth of knowledge on specific contents.
- *Data required* this involves the quantity and difficulty in gathering data and is based on the following classification, which considers the nature, ease and accessibility to the information:
  - integrated in information sources, limited effort and number of people required for data collection (in the company and among immediate stakeholders)
  - in between
  - dispersed in information sources, effort required in data collection with the need to keep contact with different and distant stakeholders.
- *Value perspective* this criterion reflects the need for the tool to consider both tangible (monetary and performance indicators) and intangible (stakeholder involvement and customer satisfaction) values in order to capture benefits from economic, environmental and social sustainability.
- *Business ecosystem perspective* the tools are able to include a broader range of stakeholders across the industrial network.

- *Innovation and creativity* This includes tools that are capable of generating innovative ideas and stimulates creativity.
- *Availability of the tool* this criterion comprises of tools that are either already available and can be used as it is (on the shelf) or needs to be adapted for the SBM process.
- *Possible use of the tool* tools vary in their use—analysis, design and guidelines. Hence, the toolset considers all of these categories, given the nature of output of each step of the SBM process.

2 Use and Test Phase

The first stage process and toolset (Table 1) were developed, which were then refined and enhanced through trials with various organisations. The SBM process and toolset were developed and tested in individual sessions with the SustainValue project industrial partners in the manufacturing industry—Riversimple, CLAAS,

Table 1 First stage SBM process and toolset

Proposed steps	Proposed tools/methods	Expected outputs
Step 1—Purpose of the business	System SWOT analysis—SUSPRONET PESTLE/STEEPLED Sustainability continuum (Willard 2005)	Reason for being in the business, approach and drivers for sustainability, products and service bundles, industry-related needs, norms and opportunities
Step 2—Identify potential stakeholders and select sustainability factors	Value mapping tool GRI guidelines, SASB (industry-specific) Scenario management tool (Chap. "Methods and Tools for Sustainable Development of Products and Services")	Potential stakeholder types and what do they value, sustainability priorities
Step 3—Explore and develop new opportunities for sustainable value proposition	Value mapping tool Scenario management tool	Sustainable value proposition for a company and its stakeholders—value opportunities
Step 4—Concept generation and selection	Sustainable business model element archetypes (Short et al. 2012) Sustainability impact calculation tool (Chap. "Methods and Tools	Transformation/development of the new sustainable value proposition

(continued)

Table 1 (continued)

Proposed steps	Proposed tools/methods	Expected outputs
	for Sustainable Development of Products and Services”)	
Step 5—Define and develop the value creation and delivery system and the value capture mechanism	Business model canvas (Osterwalder and Pigneur 2010) Life cycle cost estimation tool (“Methods and Tools for Sustainable Development of Products and Services”)	Key activities, key resources, key partners, key channels, key mindset and the value exchanges and value capture for the stakeholders

Elcon and FIDIA—and with external organisations such as start-ups, small and medium enterprises (SMEs), MNCs (multinationals) and universities—teaching material and research institutes. The feedback and observations on the efficacy of the process and tools were captured by the facilitators and participants (who vary given that the tools in the portfolio are across the project and in some cases have been used by external facilitators). The process and toolset were not all tested in the organisations, and only a subset of the toolset was used with them.

The summary of lessons learnt from the various trial sessions (Table 2) was used to improve and enhance the process and toolset. The sessions and subsequent research meetings among the SustainValue partners and external academics on the observations and feedback of participants and facilitators lead to addition and removal of tools.

Table 2 Trial sessions

Organisation	Type	Number and duration of workshops, participants and location	Overall workshop objectives for participants, tool developers and facilitators	SBM process and toolset used
Riversimple	Start-up (automotive)	2 workshops, UK Workshop 1–2 h, 2 participants—founder and engineer Workshop 2—1.30 h, 7 participants—stakeholder representatives—custodians)	Stakeholder interactions and relationships, missing stakeholders Approach to sustainable business modelling Tool improvement and validation	SBM process (whole process) Value mapping tool Sustainable business model archetypes
CLAAS	MNC (agriculture)	1 workshop, 2 h, 2 participants—service engineer and product manager, Germany	Stakeholder identification, value forms across the network, sustainable	Value mapping tool Sustainable business

(continued)

Table 2 (continued)

Organisation	Type	Number and duration of workshops, participants and location	Overall workshop objectives for participants, tool developers and facilitators	SBM process and toolset used
			business model exploration Future developments with regard to potential changes in the agricultural business environment Tool improvement and validation	model archetypes Scenario management tool SIC tool
Elcon and VTT	SME (electronics, power systems) and research institute	2 workshops, 2 days, 5 participants—2 board members, 1 employee, 2 researchers, Finland	Sustainable business model development—new offering Life cycle cost perspective for customers to select a sustainable solution Tool improvement and validation	SBM process (whole process) Sustainability continuum Value mapping tool Sustainable business model archetypes Business model canvas LCC estimation tool
FIDIA	MNC (milling)	1 workshop, Italy	Supporting FIDIA's potential transition towards a sustainable business model	Sustainability continuum (Step 1) Business model canvas (Step 5)
Furniture	SME	1 workshop, 2 h, participant—managing director, UK	Tool improvement and validation	Value mapping tool Business model archetypes
Food	MNC	1 workshop, 2 h, participant—head of sustainability and communications, UK	Tool improvement and validation	Value mapping tool Business model archetypes
Consumer products	MNC	1 workshop, 2 h, participants—sustainable development manager—products, quality and		

(continued)

Table 2 (continued)

Organisation	Type	Number and duration of workshops, participants and location	Overall workshop objectives for participants, tool developers and facilitators	SBM process and toolset used
		technology and the energy team representative		
Software/hardware products—4, manufacturing—1	5 start-ups	5 individual workshops, 1 h with 2 participants in each session, UK	Business model development Tool improvement and validation	Value mapping tool (Steps 1–3) Strategic road mapping tool with value mapping tool
Finnish furniture industry	SME network	3 workshops, Finland: Workshop 1–8 participants—representatives of network companies Workshop 2–6 participants—company representatives Workshop 3—12 participants—researchers from varied backgrounds	Network-level codevelopment of sustainability Stakeholder identification and interactions	Value mapping tool (Steps 1–3)
Genoa University University of Cambridge	Engineering students	1 workshop, 2 groups of 5 to explore two separate company cases, Italy 2 workshops, 3 h each, Cambridge: • Undergraduate—6 groups of 5, each with individual cases • Graduate—8 groups of 5, each with individual cases	Exploring various forms of value across the network to assist sustainable business modelling Tool improvement	Value mapping tool Sustainable business model archetypes
SustainValue partners workshop	Industry, academia and research institutes	1 workshop, 1.30 h, 3 groups of 4–5 participants—industry and academia, UK	Tool demonstration and improvement	Value mapping tool (Steps 1–3)
Consultants on an executive course	Consulting	1 workshop, 45 min, 20 participants, UK	Tool improvement and validation	Value mapping tool—new design and improved process
	Mix of industry and		Tool improvement and validation	Value mapping tool

(continued)

Table 2 (continued)

Organisation	Type	Number and duration of workshops, participants and location	Overall workshop objectives for participants, tool developers and facilitators	SBM process and toolset used
World[a] Federation of Sporting Goods Industry	sporting goods associations	2 workshops, 2 h each, over 50 participants, Taiwan Workshop 2 with sustainability professionals, innovation specialists, manufacturing/sourcing experts		—new design and improved process Sustainable business model archetypes

[a]Event hosted by Chinese National Federation of Industries Taiwan External Trade Development Council and Taiwan Sporting Goods Manufacturers Association

3 Sustainable Business Modelling Process

SBM process is a five-step approach that considers a network-centric perspective to deliver sustainability. The SBM process accompanied by a portfolio of tools provides companies with assistance in the analysis and design of sustainable business models for network-level change. This approach introduces the sustainability dimensions (environmental, social and economic) and objectives, language around shared-value creation across the industrial network and harmonising stakeholder objectives through the identification of conflicting interests between them. The specific difference is that the analysis of market needs is not just narrowly focused on customers, but equally on the needs and impacts on the society and the environment—that is, conceptualising a three-dimensional value proposition (economic, social and environment) for the company. The process is iterative, in that as changes occur in one step, it impacts not only on the following step but also on the preceding ones and occurs over a period of time. Companies can be at various stages of the SBM process, so using the process and toolset will rely on the preference of the participants (Fig. 1).

Step 1—Setting the scene

This step is about understanding the purpose of the business and potential stakeholders in the value network. Understanding the purpose involves developing the rationale of the business and its value. This is followed by identifying the stakeholders in the value network/s that will assist in exploring new sustainable value proposition/s. The discussion on developing the purpose and identifying stakeholders, with whom engagement needs to be established, is supported by exploring the company's position (current and future), drivers and priorities for sustainability, along with anticipated threats and opportunities.

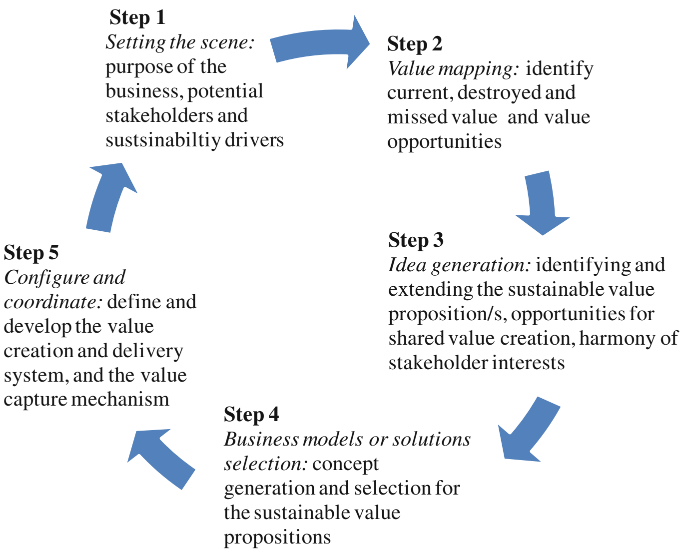

Fig. 1 Sustainable business modelling process (adapted from Rana et al. 2013; Holgado et al. 2013)

Step 2—Value mapping

This step emphasises on understanding the positive and negative aspects of the value proposition of the business and its value network. It is concerned with identifying and mapping various forms of value (current, destroyed and missed) from a multistakeholder perspective across the network to contribute towards the development of the new and/or extended sustainable value proposition/s.

Step 3—Idea generation

Based on the stakeholders established and the value mapping exercise in Steps 1 and 2, analysing the relationships and value (social, environmental and economic) exchanges between the stakeholders to eliminate negative environmental and social impacts (waste, carbon emissions, forced labour) across the network is undertaken in this step. The step focuses on identifying conflicts between stakeholders across the network and working on covalue creation (stimulating innovation and ideas) through the harmony of stakeholder interests, to develop new and/or extended opportunities for sustainable value creation.

Step 4—Business models or solutions selection

This step involves the selection of one or a combination of feasible business models, concepts or solutions for the transformation of the new sustainable value proposition or propositions (Step 3) so as to seek ways/paths to capture opportunities for value creation, while minimising negative value and maximising positive value in the network. Business models or concepts that actively seek to address sustainability are considered. This could be initiatives that encourage sufficiency—consumer awareness and education, demand management and product longevity and durability and encouraging sustainable production—closed loop (waste at the end of the use phase of a product to be used to create new value), cradle to cradle (e.g. designing waste streams that have minimal impact on the environment), reuse and remanufacture.

Step 5—Configure and coordinate

This step is about defining and developing the value creation and delivery system and the value capture mechanism for the selected sustainable value proposition and business model to generate network-level change. It involves the analysis, design and transformation of the value creation and delivery systems and the value capture for the selection/s from Step 4. It includes the identification and potential development of the value delivery and capture system (key activities, channels, resources) for pursuing options to deliver sustainability, while analysing the cost incurred through the life cycle to assist in evaluating the options. This step builds on Steps 2 and 3 on the understanding of stakeholder value and value exchanges in the network.

4 Toolset

Each step of the SBM process is accompanied by the selection of tools that will assist companies in understanding and delivering sustainability (Table 3). The selection of the tools in each step of the SBM process will depend on the user with regard to the type of the organisation, scope of operations, resource availability (human and financial), scale and size and the position on sustainability. Each tool can be used in isolation depending on the objective for use. However, they are more effective in generating results—delivering sustainability, if they are used in combination, which is exemplified in the overview of some of the tools in the following sections.

4.1 Primary Tools

The following tools were either developed or identified specifically to support the SBM process so are presented as primary tools. They assist companies in designing and developing a sustainable business model that includes a network-centric perspective for sustainable value creation.

Table 3 SBM Toolset

SBM process	Toolset
Step 1—Setting the scene	*Primary* Value mapping tool *Support* System SWOT analysis (Tukker and Tischner 2006) PESTLE/STEEPLED Sustainability continuum (Willard 2005)
Step 2—Value mapping	*Primary* Value mapping tool *Support* GRI guidelines, SASB (industry-specific) Scenario management tool
Step 3—Idea generation	*Primary* Value mapping tool Sustainable business model archetypes (Bocken et al. 2014) *Support* Scenario management tool
Step 4—Business model/s or solution/s selection	*Primary* Sustainable business model archetypes *Support* Sustainability impact calculation tool
Step 5—Configure and coordinate	*Primary* Business model canvas (Osterwalder and Pigneur 2010) Strategic roadmapping tool—emergence roadmapping method (Phaal et al. 2012) *Support* Life cycle cost estimation tool Sustainability performance framework

4.1.1 Value Mapping Tool

Value mapping tool (adapted from Bocken et al. 2013) supports Steps 1 (setting the scene), 2 (value mapping) and 3 (idea generation) of the SBM process. It assists in understanding and mapping various forms of value (positive and negative aspects of the business and its value network) and identifying conflicts between stakeholder interests, while analysing value exchanges from a multistakeholder perspective to create positive value creation for the network. It assists in stimulating innovation, generating ideas and creating new sustainable value propositions. The value mapping tool is proposed to help companies understand and create new sustainable value propositions to support business model design for sustainability. The tool was specifically designed to focus on understanding and transforming the value proposition from a stakeholder perspective for sustainability. The novel design aspects of the tool include the following (Bocken et al. 2013):

- Four representations of value to facilitate a systematic value assessment, representing the forms of value. Identifying them separately encourages a more thorough exploration of the current business model and assists in identifying areas requiring change or improvement.

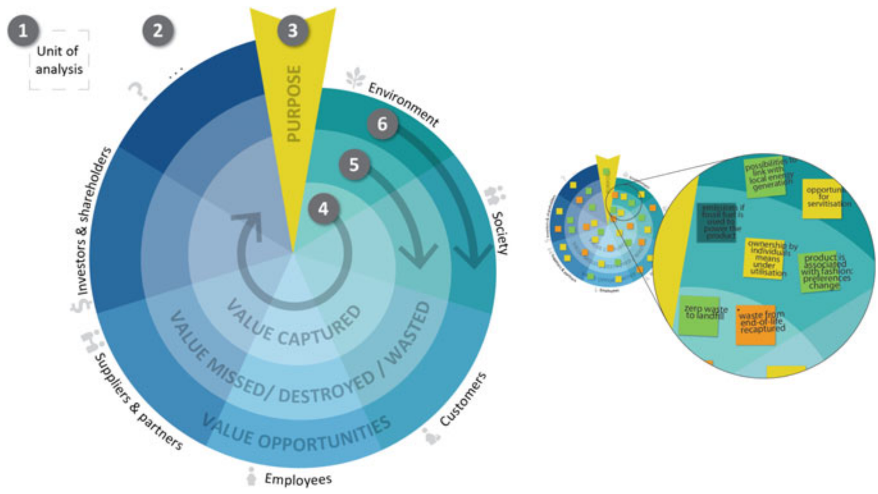

Fig. 2 Value mapping tool

- Stakeholder segments to facilitate a multiple stakeholder view of value. Current business modelling processes and tools focus on the customer value proposition. The proposed tool seeks to expand the range of stakeholders or recipients of value, including the environment and society. Each segment represents a stakeholder group.
- A network-centric rather than firm-centric perspective to encourage the optimisation of value in a network (i.e. considering all actors involved in the design, production and distribution of a product or service). The company is represented as "employees and shareholders" to facilitate a network perspective (Fig. 2).

Tool Rationale and Aim

The objective of the tool is to transform destroyed and missed value into positive new value creation and explore value opportunities for radical new sustainable value creation. The value mapping tool is based on the value transformation rationale illustrated in Fig. 3. The Riversimple industrial case elaborated in Chap. "An Industrial Case: Riversimple" provides examples of current, destroyed and missed value and value opportunities in the company.

The value mapping tool has three specific aims, which are as follows:

- Understand the positive and negative aspects of the value proposition of the business and its value network.
- Identify conflicting stakeholder interests, so pathways for generating harmony of interests can be developed to reduce negative outcomes.

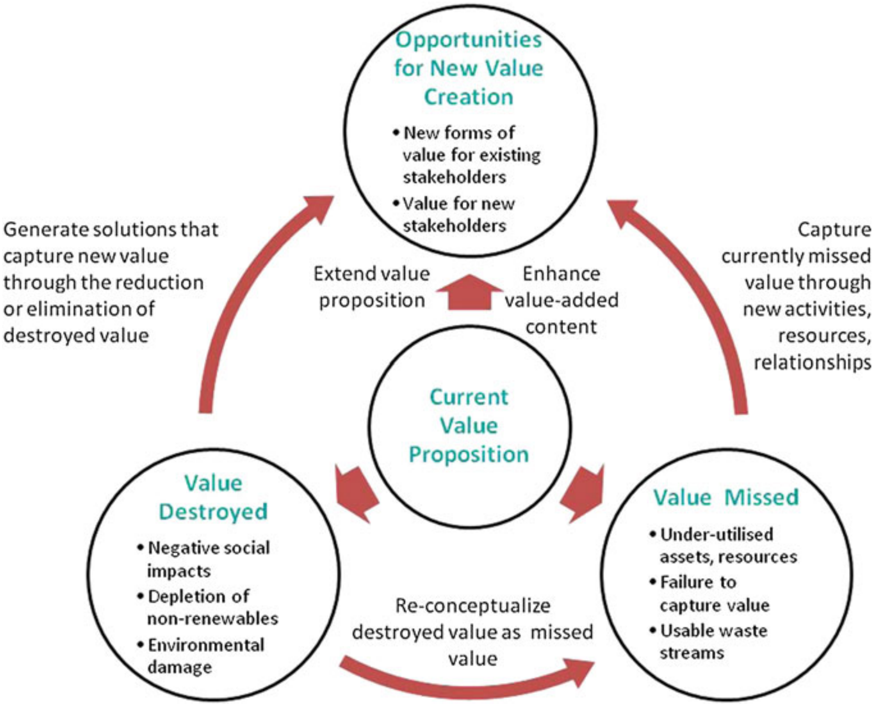

Fig. 3 Value transformation (Short et al. 2013)

- Explore new opportunities for further positive sustainable value creation through increased value-added, business extension and capturing currently missed value such as underutilised capacity.

Using the Tool

The process begins by defining the unit of analysis. The focus is on the value proposition for the overall network, rather than the company, to support a network perspective. Stakeholder types are identified and placed in each segment of the tool. Generic stakeholder types are provided, but the participants are free to populate the tool with specific stakeholders to facilitate the analysis. Hence, blank stakeholder segments are provided for potential addition of specific new stakeholder types during the process. Society and the environment are included as stakeholders. A facilitated brainstorming that includes a set of questions is then used to populate each stakeholder segment in turn with the various forms of value generated for that stakeholder. This follows a logical progression from the core value proposition by the current business model, outwards to values further removed from the core offering. The use of the value mapping tool follows the steps below:

- Step 1—Setting the scene:
  - Decide the unit of analysis (product/service, business unit, company or an industry).
  - Add or modify any missing stakeholders.
  - Identify the purpose of the unit of analysis and its network (yellow star).
- Step 2—Map the value (follow the spiral, clockwise):
  - Current value captured for each stakeholder.
  - Value missed (underutilised, failing to capture or recognise value) and destroyed for each stakeholder.
  - Identify causal relationships between forms of positive value creation and destroyed value.
- Step 3—Generating solutions for shared sustainable value creation:
  - Eliminate value destroyed—where is the conflict between stakeholders? How might it be resolved?
  - Look for ways to utilise value missed.
  - Explore new value opportunities—extending the value proposition, shifting to higher value-added activities.
- Step 4—Revisit the purpose.

Applicability of the Tool

This tool is conceived to provide a structured approach for entrepreneurs and business managers to gain a more complete understanding of the value proposition of the company and to explore opportunities for transforming the value proposition towards more sustainable solutions. The tool is envisaged to have applicability to all business modelling activities, from exploring opportunities for new start-ups, to assisting in redesigning business models for established large corporations. The use of the tool and the design of any workshops to use the tool should be adapted to the size and complexity of the business. For more complex businesses, it may be desirable to focus on specific business units or product lines to ensure the process is manageable. To maximise the potential of the tool, representatives or suitable proxies for each major stakeholder group should participate in the process to solicit broad perspectives on value.

4.1.2 Sustainable Business Model Archetypes

The sustainable business model archetypes (Short et al. 2012; Bocken et al. 2014) support Step 4 (network-level change). The archetypes describe groupings of mechanisms and solutions that might contribute to building up the business model for sustainability. They assist companies in transforming new sustainable value propositions, while designing sustainable business models, and were specifically identified and developed for this purpose. The archetypes are used in combination with the value mapping tool to illustrate the value forms and support business transformations.

The trial sessions demonstrated the value of such an approach in stimulating innovative thinking and supporting business model transformation for sustainability. The archetypes were further refined to integrate broader examples of business model innovations from practice, while enhancing and clarifying the description of the individual archetypes. The title was changed from sustainable business model element archetypes to sustainable business model archetypes as mentioned in Sect. 2 of Chap. "Sustainable Business Models: Theoretical Reflections".

As Bocken et al. (2014) state, "the archetypes have the potential to embed sustainability into business purpose and processes, increase the ambition of innovations, accelerate their introduction and reduce risks of implementation through providing exemplars from practice". The archetypes do not only reduce social and environmental negatives but also assist in redesigning and reconceiving the business model to deliver sustainability (Fig. 4).

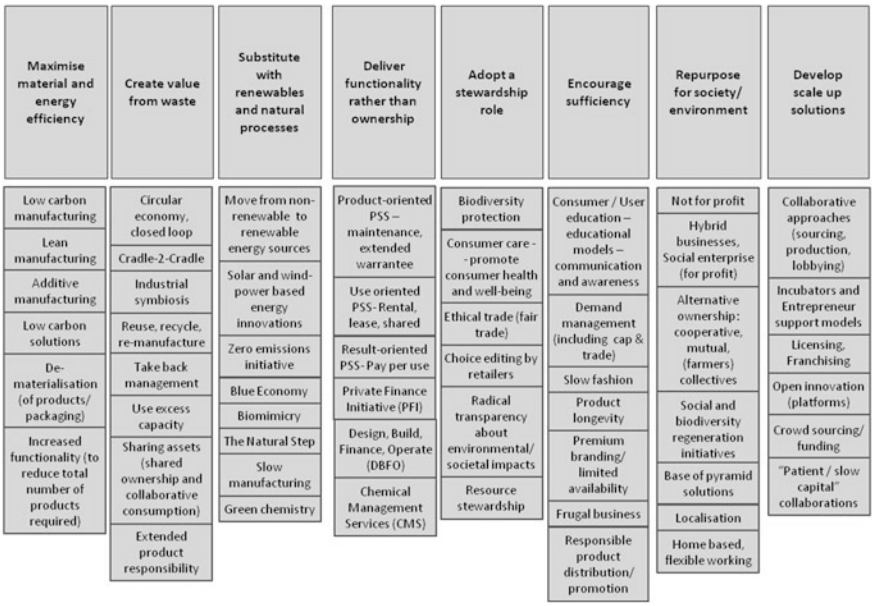

Fig. 4 Sustainable business model archetypes (Bocken et al. 2014)

Tool Rationale and Aim

With the exception of some recent literature (e.g. Boons and Lüdeke-Freund 2013 who propose a classification by social, technical and organisational sustainable business model innovations), few authors have sought to unify the various examples in the literature and practice in a useful categorisation. The lack of a common source of information in this area makes it difficult for practitioners to understand the scope of business model innovation for sustainability. This then limits practical experimentation and implementation of sustainability solutions in industry and restricts the potential for exploitation of synergies between different types of innovations, so further limiting the potential benefits. Hence, the sustainable business model archetypes were developed to describe groupings of mechanisms and solutions that might contribute to building up the business model for sustainability and identify gaps for future research agenda. The main aims of the sustainable business model archetypes are to:

- Provide a means of categorising and explaining business model innovations for sustainability.
- Define generic mechanisms for actively assisting the business model innovation process for sustainability.
- Provide exemplars that explain and communicate business model innovations to businesses to derisk the business model innovation process (e.g. through education and workshops).

Using the Tool

The set of archetypes is envisaged to provide assistance in two main ways:

- Assisting in developing the value proposition, by providing a structure for identifying and exploring opportunities for transforming currently negative outcomes of the business model, or exploring new ways to create positive sustainable value.
- Designing and developing the business model structure by providing guidance in mechanisms to realise a desired value proposition.

The archetypes and the examples are not generally entire business model innovations in their own right, but rather elements that constitute part of a business model design. The sustainable business model should be developed using a combination of several of the various archetypes for shaping the business transformation. “Although each can be applied in isolation, different archetypes may be combined and real sustainability almost certainly demands combinations of archetypes (e.g. deliver functionality rather than ownership, while maximising material and energy efficiency)” (Bocken et al. 2014). The archetypes can be used as exemplars in a workshop setting with industry. For example, it can be used with the value mapping tool as prompts in illustrating the value forms (value destroyed and missed, value opportunities).

Applicability of the Tool

The sustainable business model archetypes are conceived to provide a structured approach for entrepreneurs, business managers and practitioners to investigate mechanisms for creating and delivering new sustainable value propositions and to explore opportunities for transforming the value proposition towards more sustainable solutions. Companies when brainstorming to develop new sustainable business model ideas may draw inspiration from each of the archetypes, a creativity process that has been well received, during exploratory industry workshops conducted by the authors.

4.1.3 Business Model Canvas

The business model canvas (Osterwalder and Pigneur 2010) supports Step 5 (coordinate and configure) of the SBM process in the coordination and configuration of the value network. The canvas (also mentioned in Sect. 4 of Chap. "Business Models and Business Modelling: State of Art") attempts to capture all the dominant components of the business model (value proposition, creation, delivery and capture) and is made up of nine building blocks:

- ‘value proposition—describes the bundle of products and services that create value for a specific customer segment
- customer segments—defines the different groups of people or organisations and enterprise aims to reach and serve
- channels—describes how a company communicates with and reaches its customer segments to deliver a value proposition
- customer relationships—describes the types of relationships a company establishes with specific customer segments
- revenue streams—represents the cash a company generates from each customer segment (costs must be subtracted from revenues to create earnings)
- key resources—describes the most important assets required to make a business model work
- key activities—describes the most important things a company must do to make its business model work
- key partnerships—describes the network of suppliers and partners that make the business model work
- cost structure—describes all costs incurred to operate a business model’

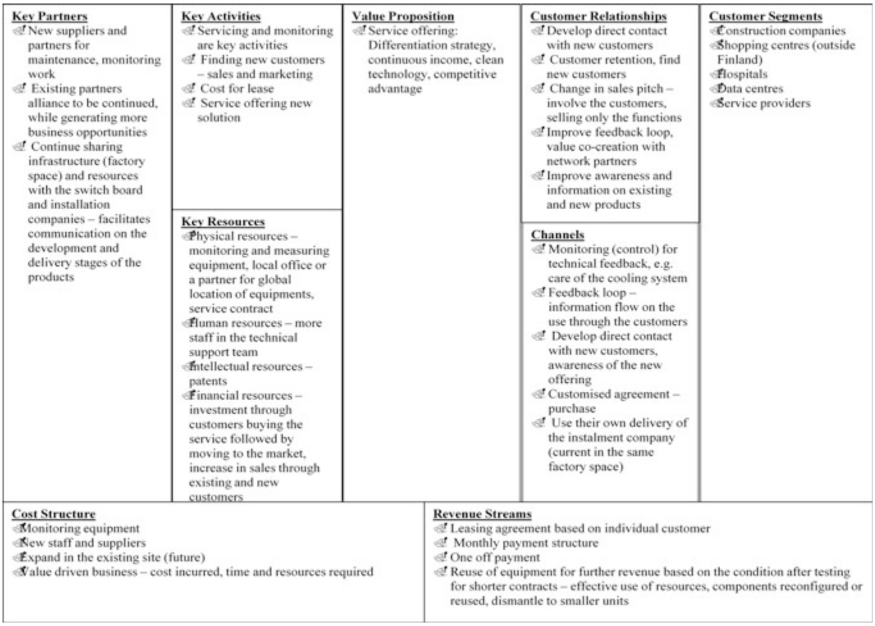

Fig. 5 Business model canvas—Elcon case example (Uusitalo et al. 2015)

The canvas places emphasis on defining concrete processes and operational activities to produce and deliver the value proposition. The preceding steps of the SBM process will explore and develop the sustainable value proposition/s with the selection of one or a combination of business models and/or solutions that will deliver sustainability. The canvas will then assist in the coordination and configuration of the key activities, key resources, key partners and channels and the value exchanges and value capture for the stakeholders across the network, while defining the revenue model of the company based on the sustainable value proposition. Figure 5 illustrates the use of the canvas with the company Elcon. The canvas was not specifically designed for sustainability, but as it addresses the key components of a business model, it is considered helpful to configure the value network for the selected sustainable value proposition/s and associated business model/solution.

Using the Tool

Using the canvas in combination with the value mapping tool and sustainable business model archetypes (tool and approach especially designed for sustainability) in a workshop setting explicitly includes multistakeholder perspective on cocreation of sustainable value. The canvas was used in combination with the value mapping tool and the archetypes, during the use and test phase with an industrial partner, while exploring their new sustainable value proposition—service offering, which falls under the “deliver functionality rather than ownership” archetype. The new sustainable value proposition, along with input on the environment, society and customers from the value mapping tool, was plotted on the canvas, hence continuing the emphasis on sustainability being at the core of configuring and coordinating the delivery and capture of the new value proposition. Figure 5 is an example of the Elcon industrial case, aligned to deliver functionality rather than ownership archetype (product service systems—use-oriented).

Applicability of the Tool

This tool is already available (on the shelf) and extensively used by the developers and external facilitators. It is applicable to entrepreneurs, intrapreneurs, consultants, practitioners in start-ups, SMEs and multinationals among others who seek to create value, develop innovative business ideas and transform businesses (Osterwlader and Pigneur 2010).

4.1.4 Strategic Roadmapping Tool

Phaal et al. (2004) view roadmaps and the roadmapping process as a powerful approach that supports “business strategy and planning beyond its product and technology planning origins” and “brings together people from different parts of the business, providing an opportunity for sharing information and perspectives and providing a vehicle for holistic consideration of problems, opportunities and new ideas”. Such roadmaps plot the identified additions to the value proposition and business model elements on a timeline from the current date to a projected end point (which could be considered as the long-term sustainability vision). The steps along the path should build incrementally upon each other, although some activities may of course be undertaken in parallel. An appropriate time frame would depend on the industry, company size and other factors. In some cases, it might be just a few months or years, others perhaps a generational planning horizon.

The emergence roadmapping method (ERM), below, developed by Phaal et al. (2012), in particular, is considered a helpful method to support Step 5 (configure and coordinate) of the SBM process. Although this roadmapping method is primarily for early-stage ventures, it is considered useful to support the transformation and implementation of new and innovative sustainable value proposition/s as “it is applicable to both the overall pattern of industrial emergence and the particular innovative efforts of companies within an industry” (Phaal et al. 2012). It “provides a structured process for [value] opportunities to be explored further, to clarify the strategic direction and to agree on technical and business development actions necessary to move forward” (Phaal et al. 2012) (Fig. 6).

The ERM was used in combination with the value mapping tool as part of “design strategy workshop for early-stage ventures” with five different start-up companies at different stages of development, run by the facilitators at the Institute

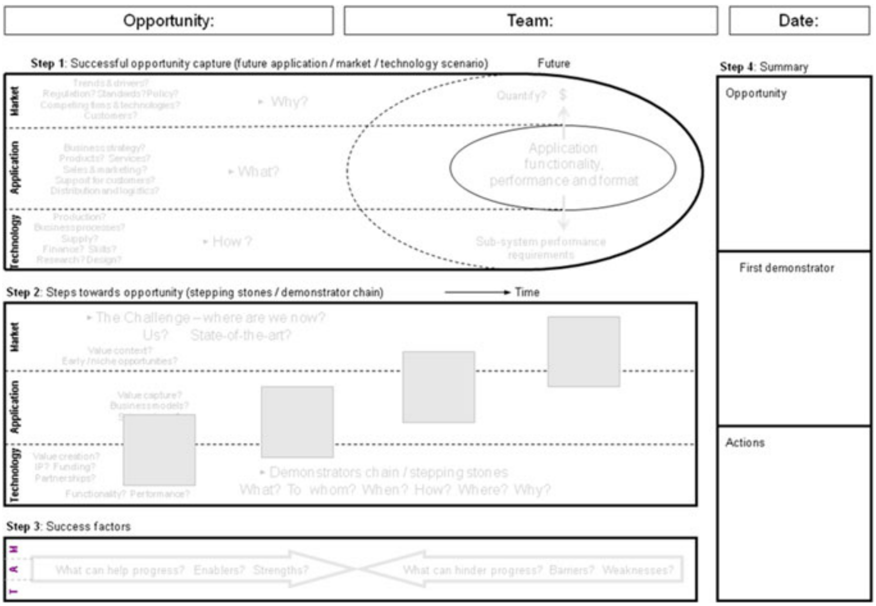

Fig. 6 Emergence roadmapping method (Phaal et al. 2012)

for Manufacturing, Education and Consultancy Services (IfM ECS). The output from the value mapping tool (new sustainable value propositions), in particular the new value opportunities, was plotted on the roadmap to develop routes towards the opportunities. Figure 7 illustrates the ERM agenda and process generated by Phaal et al. (2012). This tool is already available (on the shelf) and used by the developers in industry.

4.2 Support Tools

The tools below are used in combination with the primary tools to provide additional information and assistance in-depth analysis of the outcome.

Tools such as system SWOT analysis (Tukker and Tischner 2006), PESTLE/STEEPLED, Global Reporting Initiative (GRI) and Sustainability Accounting Standards Board (SASB) and corporate sustainability continuum (Willard 2005), assist companies in identifying industry-related requirements, norms and opportunities including the company's position (current and future), drivers and priorities for sustainability. These tools were identified to support Step 1 of the SBM process and are used in combination with the value mapping tool (based on the preference of the user). These tools and guidelines are already available (on the shelf) and have been used extensively in industry.

Timing	Activity	Description
10 min	Introductions	The workshop begins with facilitator and participant introductions.
20 min	Context presentation	The sponsor of the workshop or a nominated participant sets out the background for the workshop, including a summary of any pertinent technical and commercial information.
10 min	Aims and workshop approach	The lead facilitator presents the aims for the workshop and describes the approach, explaining how the structure and checklist provided by the template guides the group activities. The digital camera case is used to illustrate the nature of technology-intensive industrial emergence and the concept of the demonstrator chain.
60 min	Step 1: Clarify the future-opportunity scenario	Participants brainstorm ideas with a goal to articulate the future target-opportunity scenario in terms of market and application.
60 min	Step 2: Specify demonstrator milestones	Demonstrator milestones ("stepping stones") that will assist in moving towards achieving the goal are identified and described.
45 min	Step 3: Identify enablers and barriers to progress	External and internal enablers of and barriers to progress are identified, associated with the various demonstrator milestones and development activities.
15 min	Step 4: Summarize opportunity and way forward	Participants develop a short "elevator pitch" of the opportunity scenario defined in Step 1 and the first demonstrator to be achieved and priority actions to be taken from Steps 2 and 3.
20 min	Discussion and close	Workshop progress is reviewed, including key lessons and actions.

Fig. 7 Emergence roadmapping agenda and process (Phaal et al. 2012)

4.2.1 System SWOT analysis

It is part of the output of SUSPRONET project (Tukker and Tischner 2006). The generic SWOT analysis tool (strengths, weaknesses and opportunities and threats of companies) was adapted to include sustainability dimensions and technology and legislation aspects. This tool assists companies in identifying the current and future strengths, weaknesses, opportunities and threats of the business (business model) for sustainability. Such information will help towards developing initiatives and mechanisms for addressing and embedding sustainability in the business purpose and operations (Fig. 8).

SWOT	Current Situation		Future Situation	
	Strengths	Weaknesses	Opportunities	Threats
A. Environmental Dimension • materials efficiency (including water) • energy efficiency • toxics/ environmental risks • waste minimisation, re-use, recycling • transport and mobility efficiency • life cycle aspects, longevity, cyclic economy (technical/natural cycles) • bio-compatibility, nature conservation				
B. Socio-cultural dimension • fulfilment of needs/ consumption patterns (high or moderate) • health and safety issues • living conditions/ quality of life • employment/ working condition • equity and justice/ relation to stakeholders (media, NGOs etc.) • respect for cultural diversity				
C. Economic dimension ***for the company/ies*** • market position, competitiveness • profitability, added value for companies • long term business development, risk • partnership/ co-operation/ chain value captured • macro economic effect/ market influence ***for the customers*** • profitability, affordability, added value for customers (tangible/ intangible)				
D. Technology, Feasibility				
E. Legislation, Regulation, Public Infrastructure				

Fig. 8 System SWOT analysis (Tukker and Tischner 2006)

4.2.2 PESTLE and STEEPLED

They constitute extensions of the PEST analysis (Political, Economic, Social, and Technological Analysis). PESTLE includes legal and environmental factors, and STEEPLED adds education and demographic factors. They are considered as macroenvironmental factors that an organisation has to take into consideration when studying its business environment. The extension of the tool is considered as they assist companies in understanding the micro- and macrolevel factors influencing the current and future business environment. It is considered as a useful strategic tool and could potentially provide additional support to the value mapping and scenario management tool in understanding the current and future factors influencing the business environment.

4.2.3 GRI and SASB guidelines

They (serving as more as checklists) are considered helpful in providing guidance for identifying sustainability factors and priority areas. The GRI framework provides companies with guidelines for sustainability reporting based on the social, environmental and economic dimensions. SASB propose sector-specific sets of indices to reflect the different materiality issues of different sectors and emphasise on the link between business model, corporate strategy and sustainability issues (SASB website).

4.2.4 Corporate sustainability continuum

It (Willard 2005) represents the progress of a company on the path towards sustainability. It will support companies in reviewing their current and future path towards sustainability (Fig. 9).

4.2.5 Scenario Management Tool

The scenario management tool supports Steps 1, 2 and 3 of the SBM process. The tool is illustrated and explained further in Chap. "Maturity Assessment for Systematic Performance Improvement in Manufacturing". This tool supports the understanding of the micro- (values and culture in shaping businesses and market and prices, workplace conditions, various business functions—finance, manufacturing, marketing and advertising) and macro (resource use—energy, water and minerals, climate change, household/consumer behaviour and population growth)-level factors influencing the current and future business environment and identifying requirements for the future that will affect the development and transformation of a novel sustainable business model. The analysis this tool carries out is particularly relevant to Step 1. It also supports Step 3 to stimulate innovation and

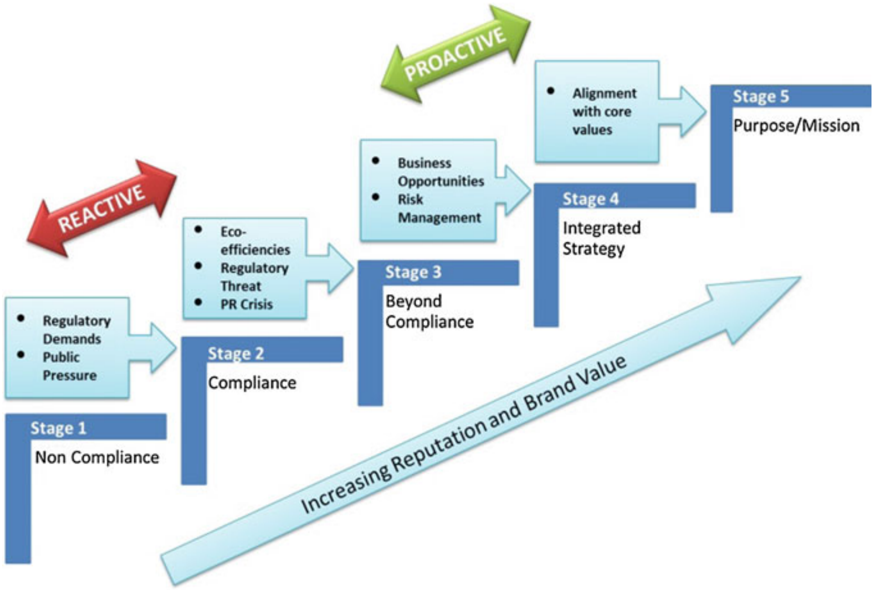

Fig. 9 Corporate sustainability continuum (Willard 2005)

understand stakeholder relationships. Hence, the tool is considered helpful to support the SBM process.

Scenario management tool is part of the future analysis, and its objective is to detect innovation potential within a defined topic. Innovation potentials are challenges that can be managed with a business model, product or service innovation in a potential market and are connected with the business portfolio. The main goal of scenario management is the description of realistic scenarios of a strategic formation field with which innovation potentials for business models, products or services can be identified. It was used to create more transparency for possible future developments related to potential changes in the environment of the agricultural business and considered all three pillars of sustainability. Economic interests and new market potentials were discussed, including investigations for potential technical developments (e.g. Internet connectivity in areas with fewer infrastructures). The identification and investigation of new environmental benefits through process optimisations were recognised, and social aspects (e.g. guidance and comfort for drivers of harvesters and tractors) were addressed.

Tool Rationale and Aim

The objective of the tool is to detect innovation potential within a defined topic by describing realistic scenarios of strategic formation fields with which innovation potential for business models, products or services can be identified. The tool is generally applicable and not obligatory to be linked to a branch or size of a company. Furthermore, the tool is user-friendly and can be used with a variable number of participants and external stakeholders.

Using the Tool

The process of the scenario analysis tool was described clearly and detailed for the industrial partners in the form of a detailed PowerPoint presentation. The different steps of the scenario management procedure (below) were supported by further templates (e.g. influence factor matrix, the idea generation sheet or the risk attractiveness matrix).

Before the tool is applied, the following tasks need to be conducted: identification of the scope for design (e.g. PSS), definition horizon and time (time period and topic) and definition of the dimension for global and local surroundings of the topic (global dimensions cannot be influenced, and local factors can be influenced). The goal of this phase is to detect innovation potentials within a defined topic. It is important to have a heterogeneous group of different actors of a company/network (optional with external stakeholders) in order to get a broader view on the topic and by respecting different stakeholder's needs/interests. Scenario management tool includes the following steps:

- System analysis and selection of key factors:
  - Identify a topic with local (factors that the company can control) and global (factors that cannot be controlled but need to be considered) surroundings. This is followed by the selection of key influencing factors.
- Development of alternative future projections:
  - This includes the description of the present situation of the key influencing factors and estimation of their future projections in a conservative, trend and progressive way.
- Grouping of alternative projections into scenarios:
  - This step involves summing up the projections into scenarios in a morphological box using intuitive and logical bundling.
- Analysis of scenarios and prospect/risk observation:
  - Chance analysis with the aid of the defined scenarios and identification of the biggest innovation potential are carried out in this step (Fig. 10).

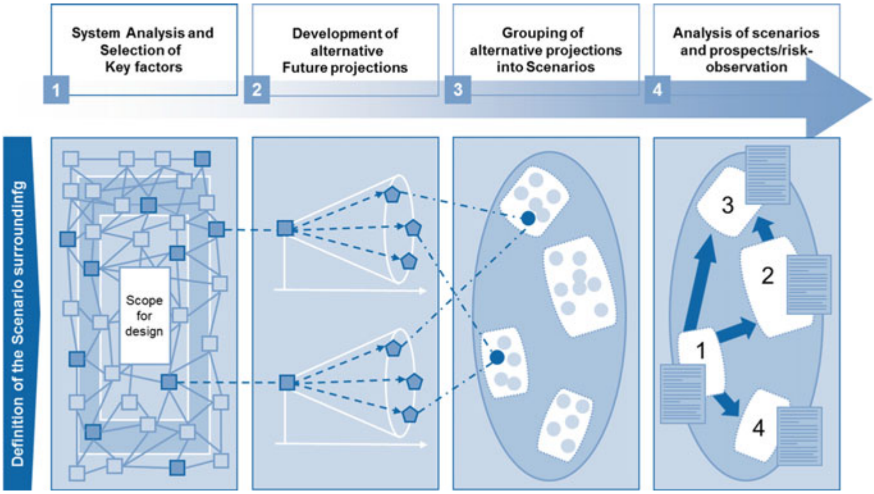

Fig. 10 Scenario management tool procedure

Applicability of the Tool

Many companies do not know the surroundings of their business and how they may change. The tool helps to develop realistic future prospects and demonstrates where future business models, products or services can be situated. It can be used in MNCs, SMEs and start-ups of all industries.

4.2.6 Sustainability Impact Calculation (SIC) Tool

The SIC tool supports Step 4 (business models or solutions selection) of the SBM process. It is illustrated and explained further in Chap. "Methods and Tools for Sustainable Development of Products and Services". This tool is included in this step as it supports in evaluating the sustainability impact across the life cycle and in the selection of sustainable solutions.

The modelling approach covers all life cycle phases (cradle to cradle) and therefore provides a holistic sustainability evaluation of a product service system (PSS). The tool combines existing PSS approaches for the detection and assessment of sustainability impacts, with sustainability aspects and thus forms a new evaluation methodology for sustainable solutions; economic, environmental and social sustainability are considered. The SIC tool demonstrates how a sustainable product or product service system performs over its whole life cycle, while covering the economic, environmental and social aspects. Economic sustainability is illustrated by the net present value (NPV) and life cycle costing (LCC), and environmental sustainability is measured via the material input per service unit (MIPS). MIPS methodology is developed by the Wuppertal Institute for Climate, Environment and

Energy which tries to measure and to estimate the environmental impacts caused by a product or service that considers the total material input and divides it into five categories (abiotic and biotic materials, air, water, erosion). Furthermore, other KPIs or methodologies are combined to assess the environmental impact. Social sustainability is measured with the aid of the Social Accountability (SA) 8000 guideline and further social aspects. The integrated life cycle concept segregates investment into separate phases over the life cycle and in this way identifies “cost drivers” of each phase.

Tool Rationale and Aim

The objective of the SIC tool is to assess and measure sustainability impacts on society, environment and economy, as well as their correlations and development over time.

Using the Tool

The first task is to stipulate a “service unit”. A service unit (SU) defines a product (or service) and its usage cycle; e.g., if the tasks would be to estimate a T-Shirt’s sustainability impact, a SU would be defined as one wearing cycle of the T-Shirt including washing and ironing. Besides, it has to describe for how many life cycles the T-Shirt will be used. Costs, such as manufacturing, raw materials, transportation and delivery, will be broken down into the defined number of service units. The result of the tool is a concrete estimation of the service unit. The tool is based on Excel calculations and consists of different files and sheets within each file. Each file represents one life cycle phase, including material input and output, social inputs and environmental, economic and social impacts. The additional output file then calculates and consolidates the environmental, economic and social impacts.

Applicability of the Tool

The tool is at the prototype stage and was used with CLAAS. However, the mode of operation is not linked to a special branch or to a size of an industry. If many companies use this tool, a wide basis for comparison can be created which can help with the classification and evaluation of service units. So the tasks for the future are to standardise the data and the evaluation of the tool with more industry partners.

4.2.7 Life Cycle Cost (LCC) Estimation Tool

The LCC tool (Uusitalo et al. 2015) is included in Step 5 (configure and coordinate) of the SBM process as it supports in the evaluation and selection of a cost-effective and sustainable solution, while providing a summary of the cost incurred across the life cycle. The tool is illustrated and explained further in Chap. "Methods and Tools for Sustainable Development of Products and Services". The LCC tool calculates and estimates the costs and effects of products during products' life cycle. With the tool, the user can compare five different solutions according to their annual and lifetime costs. Main cost categories that are taken into account are acquisition costs, use costs and disposal costs. Acquisition costs include the acquisition and installation of the components selected for the current solution. Annual use costs are costs caused by preventive and corrective maintenance, outages and electricity consumption. Power supply systems can also include components for power production (e.g. windmill or solar cells), which are taken into account as a decreased need for power from outside. All cost incurred by recycling of components or materials and waste treatment is considered disposal costs.

As a result, the tool calculates the life cycle costs of different options. Life cycle costs are shown by cost categories so that the user can make a comparison of the options by total costs and also by different categories. Life cycle profits are not considered because the power supply system is to ensure good quality of power supply, and thus, it does not provide direct profit; for example, it does not increase production volume. When considering future costs, estimates are obviously uncertain. The effect of this uncertainty is assessed by sensitivity analysis which is done by Monte Carlo simulation. In one simulation run, it is calculated life cycle costs of compared options in a case when future costs are different than what was first estimated. When this calculation is done several, e.g. 1000, times, the variation of expected life cycle costs becomes visible. As the cost factors differ case by case, this tool cannot directly be generalised for all kind of products. In this power supply system case, it is easy to combine financial and environmental aspects with life cycle costs because the main environmental effects come from electricity consumption whose monetary value can be easily measured.

Tool Rationale and Aim

The aim of the LCC tool is to bridge the gap between practical decision-making and visions about sustainable decisions. The tool supports sustainable decision-making by providing information about both investment costs and also future costs which will be realised during the use and end-of-life periods. In the power supply system case, use and maintenance costs are directly related to environmental impacts. The LCC tool includes a cost breakdown structure for the case product, data input forms, calculation of result indicators, sensitivity analysis and presentation of results by numbers and graphs.

Using the Tool

All calculations implemented into the LCC tool are done in Excel worksheets. To make the tool more user-friendly, separate forms for data input and result examination were also developed. Forms were created by Excel VBA programming language. Although data input and result examination are possible without form interface, it was implemented into this prototype because the user-friendly interface facilitates substantially better real user tests. The use of the LCC tool can be described as a process with the following steps:

- Step 1—Define the possible solutions that meet the customer's technical requirements and are options to be analysed.
- Step 2—Populate the LCC tool with input data, i.e. give numerical values to the relevant cost parameters for current case.
- Step 3—Calculate point estimates of life cycle costs. This is done automatically by the LCC tool.
- Step 4—Assess the uncertainty of numerical values of cost parameters given in the Step 2. Uncertainty is expressed by statistical distributions defined by a graphical tool implemented in the LCC tool.
- Step 5—Calculate expected variation of life cycle costs based on statistical distribution given in the Step 4. This is done automatically by the LCC tool.
- Step 6—Assess the results and compare the options using result indicators from the LCC calculation.
- Step 7—Make the decision for the current case based on economic criteria. For multivariate analysis, other criteria can be used to support the decision.

Applicability of the Tool

Life cycle cost calculations can be utilised internally in the company or externally with customers. The life cycle cost calculation can be used in negotiations with potential customers to provide more detailed cost information than just the acquisition price for their decision-making. In this case, the LCC calculations were originally meant to be utilised in the delivery project negotiations with potential customers to serve the case company's need to explain the higher purchasing price with lower life cycle costs and more sustainable solutions. The tool that was developed provides a reasonably quick and easy way to review different solutions, and it can bring new solutions that differ from the customer's first ideas about the solution into the negotiations.

During the LCC tool development and testing, the case company used the tool to analyse elements of its product portfolio. In these tests, it was realised that this kind of calculation can elicit ideas to improve products from the life cycle perspective. This internal use of the LCC tool can reveal products that are not good enough from a life cycle point of view and should be replaced with products that lead to better overall results. Applicability of the developed LCC tool is limited. Instead, the methodology of life cycle cost calculation can and has been applied widely.

4.2.8 Sustainability Performance Framework

The threefold approach to the measurement and management of sustainability performance framework is considered in the Step 5 of the SBM process to provide further understanding of the networks and relationships and the changes required. The framework is illustrated and explained in Chap. "Integrated Performance Framework for Sustainable Manufacturing Networks". The framework consists of three interlinked principal components: network conditions, internal performance levers, and outcome (triple-bottom-line assessment). The purpose of the framework is to raise awareness of complexities in the organisational environment and provide a basis for performance assessment and tracing of potentially adversarial factors inhibiting sustainability of the business as well as for improvement of sustainability performance.

The above process and tools will assist manufacturing companies in developing business models and solutions for sustainable and efficient production. They provide support at strategic and operational levels of the companies to deliver sustainability. During the industrial application of the tools, it was observed that the companies adopt different approaches and are varied in the level of receptiveness to change, to sustainability. Start-ups and small-scale businesses seem more receptive to exploring new business models and opportunities compared to larger companies (multinationals). One of the reasons may be that larger companies have relatively more rigid organisational structures and broader networks, which make exploring and adopting new ideas and business models for sustainability more gradually. A transition (transformation and implementation) path towards sustainability will follow a long-term vision with an evolutionary and incremental path, which needs to be considered when using the process and tools.

5 Conclusion

Sustainability requires systems-based and integrated solutions/processes, which necessitates better connection between the individual company's business model and the value network (or multiple value networks). As Sommer (2012) further explains, "the business model concept does not solely focus on the organisation but also considers external parties that participate in or benefit from the company's value creation activities. These external parties are not limited to suppliers or customers but also include various partners that need to be considered for any transformation effort". This transition in particular requires business model innovation to embed sustainability in the proposition, delivery and creation and capture of value through a multistakeholder view.

Business model innovation and redesign can assist in embedding sustainability into the core purpose and operations of companies, through a comprehensive consideration of a network-wide perspective to rethink the value proposition and to create, deliver and capture sustainable value. Michaelis (2002) emphasises on developing "shared goals, targets and relationships" between stakeholders in the network to understand consumption and its patterns towards improving sustainable production (resource efficiency, sustainable design and clean technologies), while "reinforcing the values that would foster more sustainable production and consumption". Business models that take into consideration sustainability issues, such as resource availability, product design, technology, consumer behaviour and aligning stakeholder value and goals, are pertinent for the manufacturing industry.

The SBM process and toolset are expected to support the analysis and design of sustainable business model/s. Business model redesign can assist in embedding sustainability into the core purpose and processes of companies. More specifically, the process and toolset provide a preliminary consideration of a network-wide perspective to rethink the value proposition and to create, deliver and capture sustainable value. Companies can select and use the tools at each step of the SBM process as per the requirement of their business and its operations.

The SBM process and tools are envisaged to have use and applicability to all sustainable business modelling activities, from exploring opportunities for new start-ups, to assisting in redesigning business models for established large corporations. Entrepreneurs, intrapreneurs, consultants, managers, start-ups, SMEs and multinationals through the use of this process and tools can gain a more complete understanding of developing sustainable business models and the value proposition of the company, and it explores opportunities for transforming the value proposition towards more sustainable solutions. The use of the tools and the design of any workshops to use the tool should be adapted to the size and complexity of the business. Further work is recommended to develop the SBM modelling process and refine tools to support the process.

There are good emerging industrial examples of companies pushing the boundaries to deliver sustainability through transitions in their businesses such as the case studies (Chap. "Methods and Tools for Sustainable Development of Products and Services"), Toyota, Marks and Spencer, Unilever, Patagonia, Xerox, Interface and ZipCar, to name a few. These adopt very different approaches to sustainability, but the common theme of these examples is that there is a sound economic business case for pursuing sustainability objectives: that is, they reduce production costs and risks and/or increase revenue and market share. A key consideration in the business modelling process described is establishing expectations and standards of sustainability performance. Assisting companies in understanding the true scope of the impact of their activities on the broad range of stakeholders and identifying possible pathways to adaptation is the only part of the challenge. The greater challenge is persuading companies to adopt challenging stretch targets to do better when the business case is not so clear or the payback period is unattractive. A better understanding of the limits of the opportunities for creating an economically viable "business case" through business model innovation will be important in helping to define future policy approaches to better encourage sustainable business models.

The research, hence, raises questions such as do existing examples of business model innovations go far enough? Are the required business transformations for sustainability really possible within the current business and economic paradigm that demands continuous economic growth, particularly for established companies that may have much to lose from radical shifts in manufacturing? What policies might be needed to support sustainable business models? Future work on exploring these questions, while further enhancing and updating the SBM process and toolset with new tools, methods and frameworks, which have a network-centric approach based on the emerging business environment and requirements, is anticipated.

The industrial practice review and use and test phase focused on start-ups, SMEs and multinationals in the manufacturing sector (production and service networks) based in or with headquarters in Europe and were tested primarily with the four industrial partners and a few external organisations due to the scope, feasibility and funding of the SustainValue project. Different perspectives may emerge if the process and tools are discussed and/osr used with a broader set of organisations in different sectors (development, finance, think tanks) and geographical locations with the possibility of resulting in interdisciplinary examples of concepts, frameworks and models that support sustainable value creation and sustainable business models. The study carried out provides an essential analysis for identifying and extending the research opportunities (suggested earlier) to other sectors and research domains.

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An Industrial Case: Riversimple

Padmakshi Rana, Nico Sergent, Samuel W. Short and Steve Evans

1 Overview

Riversimple is a UK based start-up company whose purpose is 'to systematically pursue the elimination of environmental impact of personal transport'. It was conceived to provide a personal mobility solution (car) encompassing technology solution and full service provision, adopting a total systems perspective. They have designed a highly efficient hydrogen powered electric car using a 'whole system design approach'. Riversimple has used the same whole system design approach, to develop a new business model—sale of service, radical for the auto industry but far better suited to the pressures of the twenty-first century. It optimises the entire system of designing, manufacturing and providing vehicles to customers in a more financially and environmentally sustainable manner. Based on the 'sale of service' model, Riversimple will retain ownership of the vehicle throughout its life; customers will pay a fixed monthly rental and variable per mile charge (Riversimple will pay for fuel and maintenance). Where the traditional car 'ownership' model rewards obsolescence and rapid vehicle turnover, the sale of service model rewards longevity and resource minimisation. In particular, Riversimple is adopting a shared ownership governance model, which gives capital providers, employees, customers, neighbours, the environment and commercial partners a shared voice in the business. This will encourage better, more relevant and more responsible decision-making, which will result in a more profitable business (Fig. 1).

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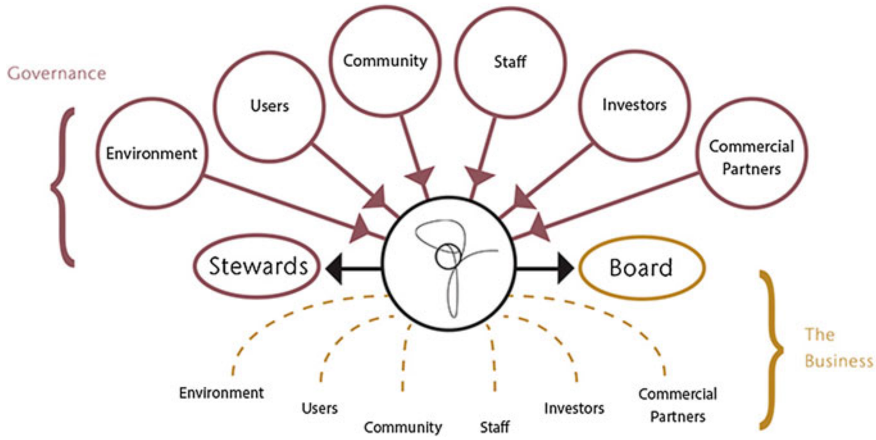

Fig. 1 Riversimple's governance model (Riversimple website)

2 Riversimple and SustainValue

The case study was carried out in a series of interview, meetings and workshops with the founder, engineer and stakeholders (custodians) of Riversimple. The Riversimple case study elaborated in Chap. "Practice Review of Business Models for Sustainability" provides information on the Company's sustainability and business modelling approach. Work Package 2 team worked closely with Riversimple to explore and develop an understanding of business model innovation for sustainability and the integration of sustainability into their business purpose and process. The company was further involved during the development of the sustainable business modelling (SBM) process and the tools such as the value mapping tool and sustainable business model archetypes to discuss and test potential ideas and the tools. The lessons learnt during the trial sessions were used to improve and enhance the process and toolset. The Riversimple use case description in the project emphasises on implementing sale of service principles and goals to optimize the interaction between the company, their customers and suppliers identifying the stakeholders and their relationships; and work towards managing the relationships.

2.1 *Results and Impact*

The following sections will elaborate on the results and impact generated for Riversimple through the use of the SBM process and following tools:

- Value mapping tool
- Sustainable business model archetypes

Table 1 Riversimple's approach and initial SBM process

Riversimple's approach	SBM process (see Chap. "Toolset for Sustainable Business Modelling" for first stage SBM process)
Objective of the business (influences on the purpose and business model—the natural step, natural capitalism, fuel cell technology, chaordic commons)	Step 1 Purpose of the business
Governance model development (employee ownership, 'develop a governance system in the interest of society', self governance)	Step 2 Identify potential stakeholders and select sustainability factors
Value proposition definition—sale of service	Step 3 Idea generation: explore and develop new opportunities for sustainable value proposition
Systems approach exploration—network configuration, open source	Step 4 System level selection
Investment mechanisms—government grants, private investors, long-term vision)	Step 5 Define and develop the value creation and delivery system, and the value capture mechanism

- Development framework for sustainable solutions
- Sustainability performance framework—Integrated assessment platform for sustainability performance

SBM process

As Riversimple's business model is focused on sustainability the goal of testing the SBM process was too see if it applies to Riversimple's approach, while generating further understanding about their business modelling process. This was considered helpful in identifying areas of improvement and validating the SBM process. The following is the summary of observations from the session:

- The process is similar to that of Riversimple's, but a further improved process was suggested based on the company's experience, in particular for steps 3 and 4 of the SBM process (see Chap. "Toolset for Sustainable Business Modelling"), focusing on clarity in the transformation phase. Below is the SBM process with the suggested changes against Riversimple's overall approach (Table 1).
- Some of the key challenges for Riversimple include relationships with stakeholders (for example—investors, suppliers), funding, self regulation, principles and value
- The SBM process is ad hoc and iterative, as in Riversimple's case
- Visionary leadership was mentioned to be important to drive the business modelling process as suggested in the previous interview and meetings with the company

The SBM process is a guiding set of steps whose output/s is demonstrated through the use of various tools supporting each step. For Riversimple the process for developing a sustainable business model spanned across a period of time. One of the key influences on their approach, which was also considered in the development of the SBM process, was The Natural Step approach. This is a '5 level framework—systems, success, strategic, actions and tools' with tools such as the four system conditions (sustainability principles based on physical resource use and availability and 'people's capacity to meet basic human needs'), funnel ('metaphor to visualise social, economic and environmental pressures on a growing society'), backcasting and life cycle assessment (FSSD guide, 2008). The framework is based on whole systems thinking and recognises the need for understanding interactions, relationships and impacts between stakeholders/actors in the system. Whole systems thinking as mentioned by the Founder is significant to the purpose of the company and the premise for development and implementation of the business model.

Value mapping tool and Sustainable business model archetypes

Through the use of the tools, Riversimple has gained in-depth knowledge of the value streams of all key stakeholder groups (investors, staff, customers, commercial partners, local communities and the environment). Understanding these value streams is fundamental to the business as, within the Riversimple structure, the legal duty of the Board is to balance and protect these. The company gained valuable information on the relationship between stakeholder groups and potential conflicts. Managing the relationship is very important and the tools have helped in formalising this as a process. Information was gained in terms of business modelling itself. Riversimple's founders had created business strategies focussed on sustainability from years of experience and learning, but without using any formal method and tools.

Development Framework for Sustainable Solutions

Using the framework, Riversimple realised that its approach to developing strategies pushed the ideation phase further than usual; leading to more sustainable overall solution. The ideation includes not only the conceptual phase but also covered the operational side. By thinking the entire process through to manufacturing, distribution, use and end-of-life, Riversimple was able to consider more aspects of the sustainability of the entire business.

Performance Measurement Approach

Riversimple participated in a workshop lead by UiS and POLIMI, to receive information about suitability, consistency, completeness and applicability of the approach through the discussion of it's attributes and questions. This, in turn, assisted Riversimple in further analysing its governance structure and stakeholders of the company.

3 Results

Below is the overall summary of results generated through the use of the tools for Riversimple:

- The first result for Riversimple was the formalisation of the value streams for each stakeholder groups (Table 2). This lead to a much better understanding of the company goals for everyone involved in this fast growing business. This has also helped in inducting new employees.
- The work with project partners resulted in the creation of a new company governance structure. Riversimple had an LLP (limited liability partnership) legal structure to accommodate the multi-stakeholder governance strategy. Unfortunately the LLP legal framework had some limitations (regulated as a collective investment scheme) and considerable work was done to change the

Table 2 Value streams of Riversimple

Stakeholders	Value captured	Value destroyed and missed	Value opportunities
Customers/users	Provide private movement: • at low cost • with a full service model therefore it means that the manufacturer aims for good service level aligned with the user Users in developing countries may access the car as it is made locally for that market Open source knowledge of production keeps cost low and standards high	Allow everyone over 17 to use a car Encourage the user to commit to the wrong fuel technology The car may not prove to be as safe (as a driver) as the user is led to believe Colour of the car fades, so could be the wrong colour Insurance is high	If Riversimple develops quicker, all benefits can be achieved Potential market could be increased by engaging prospective users via social media and allowing people to follow the project dynamically
Investors	Stable and sustainable income/return Long term robustness Know-how on sustainable business models from Riversimple and other custodians Positive reputation impact	Inherent risk Long return horizon Uncertainty about the governance structure—how it will work out Exit opportunity not clear Value missed—not using existing know-how to generate return, working with existing auto industry elements—suppliers, financing, dealerships/service agents	Build a simple vehicle with existing know-how or put in open source Get partners from industry actively involved to add credibility/de-risk/make sure customer needs are met

(continued)

Table 2 (continued)

Stakeholders	Value captured	Value destroyed and missed	Value opportunities
Staff	Work impact: • Good pay • Great relationships formed • Sunday dread reduced/removed Work life: • Opportunity for growth • Positive effort by all to do better—performance • Passionate people to work with • Trusting relationships • Equitable conditions • Nice place to work	Size of the team Social isolation Location contentious for some Caught in the same project Uncertainty for the future	Enhance the local environment Work with other organisations Provide diversity Good communication with employees
Environment	Addresses: • climate change and local air pollution from the internal combustion engine • peak oil • waste from vehicles at end of life The service user agreement demonstrates an environmentally driven route to supply of technology The governance structure puts the environment t the heart of the company's purpose rather than an add-on Access to a wide range of innovative ideas, many of which should realise sustainability	Encouragement of private car use which even with Riversimple's car will still cause damage from traffic and road building, Continued emissions caused if the hydrogen used is from fossil fuel burning or risks from radiation if generated from nuclear plants Encouragement of continued private car use leading to further decrease in public transport use Emphasis on building cars which are appealing rather than utilitarian (vans), which promotes car culture rather than the essential need for sustainable vehicles for deliveries etc.	Opportunity for an industry that has negative environmental impacts to adopt new ways Use of the fuel cell to use energy in the home when the car is parked Community hydrogen generating plants from wind turbines operating at times of low electricity demand Reinvigorate repair industry by demonstrating how design is essential for ease of repair
Neighbours (local communities, councils)	Impact on the local economy—local employment, quality of employment Funding local services through taxes Sense of community and for growth—culture/education/diversity	Pollution, noise Increase in local population—infrastructure impact/transport Greater strain on local services Change to quality of life—dilution of culture Disrupted community Change in land use	Promote the positive: • ethos of Riversimple • media attention the company will bring to the local area • infrastructure, employment and education benefits

legal structure to a conventional ltd (Limited Company) where the SBM data showed that such a structure was workable.
- The tools were used to help formalising the new structure. They were also used to help define the exact role of the stakeholder representatives (custodians).

3.1 Impact

Given the novelty of Riversimple's business model it is no surprise that there weren't any fundamental changes in the business model or strategies through using the project tools. However, the tools led to a better and deeper understanding of the implication of having a multi-stakeholder governance structure. The formalisation of stakeholder benefit streams has had a positive impact on the business as it helped in defining and more importantly communicating the company strategies. This will have a long term impact on the efficiency of the business. The use of the value mapping tool has had clear beneficial impact on the communication between custodians (stakeholder representatives). This will also have a long term impact and improve the way Riversimple works.

A significant impact of the work resulted from the tools are linked with the change in company legal structure. The project helped in implementing a multi-stakeholder governance model in a conventional Ltd legal structure, which has had a very positive impact on the way potential investors see the company. Adopting a company limited by guarantee (ltd) structure has led to much better interaction with the wider investment community.

3.2 Next Steps for Riversimple

- The new governance structure has just been implemented and custodian roles and processes defined. The next steps will be to test of the processes and evaluate the structure.

Photo 1 SBM session

Photo 2 Stakeholders workshop

- The SBM tools will be used again at a later stage to re-evaluate the progress made and potentially identify further improvements.
- Following the next growth phase of the business, Riversimple expects to use other tools in the project to assess the business at a more mature development stage (Photo. 1 and 2).

Part III
Life-Cycle Based Sustainable Solution Development

This part deals with the development of sustainable solutions. As mentioned in the first part of this book companies face new challenges. They have to achieve economic goals and at the same time meet environmental and social objectives. Product service system can serve as an enabler for sustainability. Several advantages and successful case studies have already been described in early chapters. At the same time the necessity for a development framework has been highlighted. In this section the development framework for sustainable solutions are presented. As a basis general requirements for processes are collected and analysed. In a next step current methodologies are explained and checked against the aforementioned requirements. For the purpose of illustration these methodologies are assigned to different life cycle phases. Based on the results a gap analysis for the development framework is conducted. In the next step the development methodology is introduced. It is shown that there are several possible paths for the development of sustainable solutions. For every development dimension and every development phase stages and gates are presented. The stages contain possible methods and the gates serve as checkpoints to reach the next stage. The last chapter of this part provides the reader with a considerable tool box.

Requirements for Sustainable Solutions Development

Christian Grefrath, Dirk Wagner and Sebastian Stermann

1 Introduction

The aim of this chapter is to collect internal and external, abstracted requirements which are necessary for the development process or the sustainable solution itself. The first part describes the characteristics and the requirements for sustainable solutions (Sects. 3, 4). The following part (Sect. 6) describes different development procedures and the requirements for an efficient and effective development process to realise a sustainable solution. It will be described how a procedure has to be designed to ensure the development of a sustainable solution. First of all, a guideline is given how requirements should be systematically identified to develop a sustainable solution.

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2 How to Develop Requirements for Systems

Tukker and Tischer question the inherent sustainability of product service systems (PSS). PSS have many advantages concerning sustainability (see Sect. 4 in Chap. "Products and Services in a Sustainable World"), but they have to be imbedded into a development process. Thus, requirements for systems in general have to serve as a basis for sustainable solutions.

There are several procedures describing how to deduce requirements for systems in general. Some procedures describe the definition of requirements for the area of product development or the area for the service development. Some other procedures describe the area of development process of software (Conrad 1998; Pahl et al. 2003; van Husen 2007; Rupp 2004; Wallmüller 2004; Schienmann 2002; Macaulay 1996; Nuseibeh and Easterbrook 2004; Pohl 2004; Spath et al. 2001). The most important steps of the different procedures can be aligned to the guideline below. Besides these criteria, a guideline exists which should be followed if requirements for a specific solution are formulated. The steps are shown in Table 1.

According to this guideline, this document synthesises requirements for sustainable solutions on a generic level in different steps. In the first step, different sources from the literature are integrated. Additionally, further identified requirements from different perspectives in terms of workshop findings are combined. Secondly, a structure of the requirements has to be set up. As a third step, lists of requirements are presented.

Table 1 Guideline to define requirements (adapted from van Husen 2007)

General procedure	Specific steps for identification of requirements for products, services or software
Collection of all requirements	Integration of different stakeholders to get a complete list of requirements from different perspectives
	Detection of all requirements in secondary sources (e.g. literature, specifications)
	Definition of technical data
	Challenge the requirements by the use of detailed questions to clarify the aim and the characteristics of the requirements
	Procure information to describe the requirement in detail
Structuring of requirements	Structuring of requirements if a possible structure can be found
	Discussion of requirements
	Analysing requirements considering the given criteria
Set up the list of requirements	Set up a consistent list of requirements
	Sharing the list to all involved participants
Verifying and complementation of requirements	Define responsible persons
	Consideration and documentation of changes
	Final acceptance of prioritised requirements

To set up a structure for the requirements, the life cycle phases of solutions will be introduced in the next section.

3 The Life Cycle Phase of Solutions

In Chap. "Towards Sustainability governance in Value networks", the concept of sustainability was introduced and a basis understanding of product service systems (PSS) was given. The life cycle phases of solutions are an important element to be taken into account during the development of sustainable solutions. While DIN ISO 15226 (1999) states that there is not a single definition for a product life cycle and that it has to be defined on a case-by-case basis, a basic product life cycle can be defined as the time period beginning with the first idea and ending with the disposal of the product (DIN ISO 15226 1999). A structuring example consists of eight phases: beginning with the concept, design, planning and sourcing followed by manufacturing and distribution and ending with service support and end-of-life activities. Each phase has individual requirements concerning sustainability, and all have to be taken into account from the beginning as they might be contrary. Furthermore, this concept can be used as a basis to structure the requirements. In the next sections, requirements for sustainable solutions will be identified.

4 Generic Requirements for Sustainable Solutions

In this section, requirements for sustainable solutions are presented which are based on the literature research and workshops conducted at the FIR. The challenge to identify requirements for sustainable solutions is to choose a suitable level of abstraction. It is necessary to define requirements on such a level of abstraction that the derivation of specified requirements for special solutions must be possible in different branches and for different solutions.

In the first part of this section, results from the literature research are listed. Then, the results from workshops and practical experiences are presented. In the second part, the summarised and abstracted requirements are given in Table 2.

4.1 Requirements Collected from the Literature

In this section, relevant literature sources are briefly summarised and the main requirements derived from the literature are presented. The content of some literature is corresponding. Thus, not every requirement presented in each source is listed below.

Table 2 Requirements for sustainable solutions

Life cycle phase	Requirements
Design, planning and development	Requirements concerning complexity management and modularisation
	Requirements concerning configuration principles
	Requirements concerning design, construction and durability, in particular how the environmental, customer and social requirements can be aligned with the company's interest and economic expectations
	Requirements concerning costs and benefits as well as added value
	Requirements concerning environmental impacts
	Requirements concerning innovations and technology
	Requirements concerning human rights, cultures and occupational safety
Sourcing and manufacturing	Requirements concerning business relationships
	Requirements concerning transparency of used components and goods
	Requirements concerning the manufacturing of the solution
	Requirements concerning the value network
Distribution, logistics and services	Requirements concerning education and assistance
	Requirements concerning suitable services (monitoring, inspections, consultancy, ICT solutions, etc.)
	Requirements concerning delivery chain/networks
Usage	Requirements concerning consumption of energy, water, materials, air and land
	Requirements concerning emissions and waste
	Requirements concerning efficiency and intensity of usage and maintenance
	Requirements concerning the continuous improvement
	Requirements concerning safety and health
End of life, reusage and recycling	Requirements concerning recyclability and reusage

NaNuMa

The aim of the project "NaNuMa—Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" that was funded by the German government department was the development of sustainable life cycle concepts for products and services. Within this project, requirements for sustainable life cycle concepts have been defined. The identified requirements from this project are to handle complexity, extend durability, use modular structures, increase recyclability and repairability, combine functionality and reduce consumption, costs and waste/emissions (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006).

Tukker and Tischner

Other requirements for sustainable PSS are given by Tukker and Tischner (2004). The idea behind the approach is the (relative or absolute) decoupling of economic growth and the environmental impact. Many authors believe that PSS contribute this mentioned decoupling. Therefore, some requirements for sustainable solution can be found in (Tukker and Tischner 2004, 2006). The authors require, i.e., a longer utilisation of goods, systems solutions and more intensive utilisation of goods, sufficient solutions, dematerialisation, economic incentives, compliance with international labour laws and human rights, as well as legal requirements, maintaining the skills, wages, health and benefits from company personnel and respecting social, religious and cultural norms.

Meier

Also, Meier mentioned some reasons why PSS contribute to sustainability. Additionally, to the 3 pillars of sustainability, he describes a fourth aspect of motivation. The four reasons to sell more PSS instead of single products or services to customers are ecological, environmental, social and technical driven (Meier 2011). According to Meier, a PSS must generate more benefits and revenues, has to ensure job security in high-wage countries, leads to innovation and reduces the consumption of resources.

Schweitzer

Further requirements concerning the life cycle management of PSS give Schweitzer (2010). Originally, the life cycle management method aims to optimise the economic and ecological efficiency in all life cycle phases of a product. If this method should be used for the planning of PSS instead of a single product, some changes must be done. Therefore, Schweitzer describes some requirements which must be considered. The products and services should support each other through the whole life cycle to meet customer demands and to be economically and ecologically efficient. Furthermore, consistent standards throughout the value network must be established to collect information about the utilisation of the product and the current market situation. This information must be used as a basis for the implementation of a continuous improvement process (Schweitzer 2010).

LPNI Systematic

Another method that delivers further important requirements is called "LPNI systematics". LPNI stands in German for "Lebensdauerausweitung (L), Produktnutzungsverlängerung (P), Nutzungsintervalloptimierung (N) und Nutzungsintensitätssteigerung (I)", which means "extension of life cycle (L), extension of product usage (P), optimisation of the use phase (N) and raise of use intensity (I)". Meyer developed this LPNI systematic which is based on previous fundamentals of Stahel (Stahel 1991; Meyer 2002). The aim of the LPNI systematic is to enlarge the usage of a product in the two dimensions time and intensity of usage without increasing the ecological impact. Figure 1 shows how the four LPNI strategies enlarge the usage of a product (adapted from Frink 2005).

There are some important requirements which must be considered to apply the LPNI systematics successfully. These requirements are in general useful to enlarge the usage of a product and to contribute to a more sustainable solution. Some requirements collected from Frink are with regard to the design. The design must

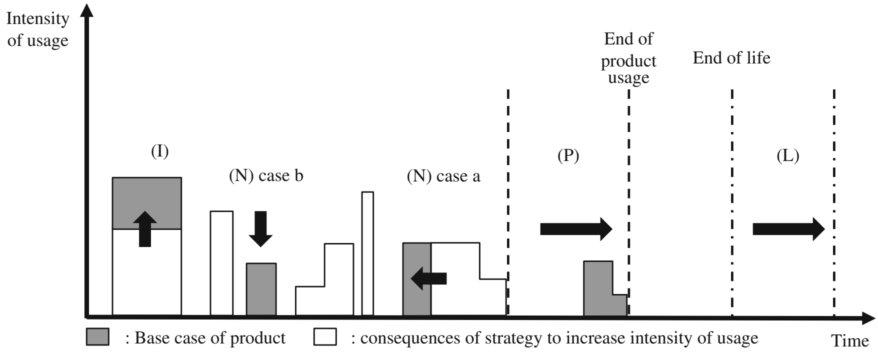

Fig. 1 Principles of LPNI systematics (adapted from Frink 2005)

be, i.e. modular and stable, and has to meet the requirements. Furthermore, he requires a concept of maintenance and spare part management and the usage of product sharing (Frink 2005).

4.2 *Requirements Derived from Workshops and Practical Experiences*

The collected requirements from the literature show how differentiated requirements for sustainable solutions could be. According to the procedure to define requirements, which is described in Chap. "Perspectives on Performance assessment and management", not only requirements from secondary sources (literature) should be considered. Requirements from different stakeholders must be identified trying to fulfil a complete collection of requirements for sustainable solutions. Workshops are a good basis to derive practical requirements for sustainable solutions. Most of the requirements that were identified in several workshops directly refer to specific cases. That is why the following list does not represent the original formulated requirements but rather the generalised requirements for sustainable solutions as an outcome of the workshops:

- Add learning opportunities in solutions for customers and consumers concerning sustainability.
- Calculation models of sustainability supporting the transparency of the ecological and social impact.
- Use renewable energy streams and renewable resources for manufacturing.
- Integrate closed-loop systems for synthetic materials for recycling.
- Consider safety aspects of products and services to ensure the health of customer or stakeholders (e.g. free of harmful substances, pedestrian safety).
- Solutions should give incentives for user to act in a responsible manner concerning social or ecological manners.

- Design of the solution should ensure that nearly all waste streams are absorbed.
- Intelligent products that are monitoring, supporting and interacting if they detect dissipation during usage.
- Use of modularised or platform concepts.

4.3 Conclusion of Generic Requirements for Sustainable Solutions

The following table (Table 2) summarises the identified requirements which are deduced from the literature and workshops with industry. To provide an overview about the variety of requirements, the following conclusion is on a generic level. An exemplary life cycle helps to structure this list of requirements. The requirements listed below represent areas of requirements. The previous chapters give more detailed information within these identified areas.

5 Definition and Characteristics of Relevant Development Methodologies

Along with the introduction of product and service combinations, new methodologies for the systematic development of solutions have been developed by combining the theories of product and service development. While there exists a widespread consensus and extensive theory in the academic literature about the economic benefits of solutions, methodologies for the integrated development of product and services are far less numerous (Thomas et al. 2010). In order to derive a suitable model for the creation of sustainable solutions, common key elements of existing theories from the field of product, service and integrated product service system development have to be identified. Hence, the following paragraphs will give an exemplary view of these three fields of research.

5.1 Product Development

Theories for systematic technical product design have existed for decades and evolved into a great number of theories. Pahl (Pahl/Beitz 2006), for example, lists more than forty important international publications on the matter. Further references can be found from, e.g., Ulrich and Eppinger (2000). VDI (Verein Deutscher Ingenieure—Association of German Engineers) Guideline 2221 (VDI Guideline 2221) has established itself as a de facto standard, especially in German-speaking countries (Thomas et al. 2010). It divides the technical development process in four phases:

- Analysis
  - Formulation of a requirements list.
  - Abstraction of the planned system in the form of a black box model.
  - Functional analysis, meaning the segmentation into independent subsystems.
- Conceptualisation
  - Construction of variants of solutions for each subsystem based on idea generation methods.
  - Development of a morphological box to combine individual solutions.
  - Evaluation of variants via *cost utility analysis* or similar methods.
- Design
  - Development of blueprints for the final solution.
  - General calculation for the specification of part dimension specifications.
- Elaboration
  - Execution of all needed calculations.
  - Creation of technical documentation.

In conclusion, product development models have not evolved fundamentally over the last years in engineering literature. Generally, their focus is on technological systems without a reference to additional services beyond traditional maintenance (Gausemeier 2000).

5.2 Service Development

The creation of systematic methodologies specifically for services has gained traction since the 1990s (Thomas et al. 2010). Many companies were confronted with the problem that their business structure and business processes were no longer efficient in terms of service development and offerings. There existed no strategic process which defined the development process of services. Most of the businesses did not use a precise definition of their service offerings; relevant processes and resources did not exist (Bullinger and Scheer 2006). However, as services became a crucial factor in competition and a unique attribute of a company, academia, in particular Bullinger and Scheer in Germany along with the New Service Development of Johnson, Edwardsson and Olson in the USA (Scheuing and Johnson 1989; Edvardsson and Olsson 1996), began to develop exact processes and methods how to develop services—becoming what now is known as service engineering.

Bullinger (Bullinger and Scheer 2006) sectioned the service development process in six phases that cover all necessary steps from a service idea to its implementation onto the market. The author defines service development as a closed-loop process, which does not stringently begin with the starting phase, but is a constantly moving and improving process. The circle also expresses the flexibility of a service engineering process. The different phases do not have a clear linear order of action. In the starting phase, several service ideas are generated and are evaluated in the following analysis phase whether supply and demand requirements are covered. If the idea meets these requirements, one can continue with the conception phase. If the defined requirements cannot be fulfilled, the starting phase needs to be recapitulated. The main task in the conception phase is to specify the developed idea in potential, process, result and market dimensions and later integrate all components into one specification as a whole. Subsequently, in the preparation phase, the needed resources will be provided so that the new service can be tested. The testing phase is necessary as to identify gaps or weak spots of the service. Eventually, specifications that have been developed in the conception phase need to be overhauled. In the end, the service can be implemented in the market.

5.3 Product Service System Engineering

Increasing market demands and the constant need to differ from competitors forced companies to enlarge their product range. Combinations of products and services formed a new possibility to create customised solutions and to break away from business competitors. The borders between products and service slowly disappear. At this point, companies face a new problem: how to develop such new "products" that do not only contain goods but also contain services? Therefore, new development concepts were generated: product service system engineering (PSSE) (Thomas et al. 2010).

Aurich et al. (2007), for example, describe the product service system engineering process as life cycle management (LCM) that includes two product life cycles: first from the manufacturers' perspective, where all activities from the idea generation until the implementation as well as the value creation networks are considered, and second, the customers' perspective which represents the using phase of the LCM.

Step 1 Organisation:

- Sequence planning and organisation in order to lay the foundation for the LCM.
- Standardised components are collected in a process library.

Step 2 PSS planning:

- Idea generation by considering specific demands of producer and customer.

Step 3 PSS development:

- First: planning of project development.
- Deduction of an operation chart from specifications that are separated into products and services, which consist of small specific subtasks from the process library.

- Division of the process into several components enables a consistent communication between construction and service development.

Step 4 PSS implementation:

- Bringing onto market of the PSS, which includes the delivery and configuration of the customised PSS but also the permanent provision of the connected services during the usage phase of the customer.

5.4 Product Service System Engineering and Sustainability

Tukker and Tischner (2006) discuss whether product service systems are automatically more sustainable than "conventional" product-based productions. Sustainability aspects do not come automatically with PSS on its own, and they need to be considered and integrated on purpose into the development process. The authors have evaluated thirteen PSS development methodologies. In conclusion, a clear converging pattern in the form of three main PSS development phases in the reviewed methods is identified by the authors.

Step 1 Analysing

- the current situation,
- the reference product/service,
- the customer needs and expectations,
- the internal situation of companies and their external (potential) partners, thus exploring and identifying new business opportunities in the PSS area.

Step 2 Creating and detailing new ideas.

- Based on the findings or the knowledge available about business opportunities, new ideas for PSS are generated.
- The most promising ideas are selected.
- The selected idea is detailed.
- Evaluation shows whether the detailed concept is good enough to be realised.

Step 3 Realising the detailed concept.

- Preparation of market launch, developing marketing strategy.
- Production of the material and immaterial parts of the PSS.
- Market testing.
- Market launch.
- Evaluation of success of concept.
- Review of the PSS development process.

6 Requirements for a Development Process for Sustainable Solutions

As mentioned before, plenty of engineering processes already exist. The general requirements from the literature referring to a development process are collected and presented in this section. Most of the requirements can be assumed for the development of the sustainable engineering approach. Some relevant requirements cannot be deduced directly from the general requirements for the development process. The requirements for sustainable solutions that are discussed in Chap. "Maturity assessment for Systematic performance improvement in Manufacturing networks" influence the requirements for an efficient development process. To meet the requirements for sustainable solutions, the development process has to meet the requirements listed in Chap. "Maturity assessment for Systematic performance improvement in Manufacturing networks". Unlike the previous chapter, the requirements presented here are separated into requirements concerning the process and requirements concerning the output. In the following table, the requirements are summarised according to the proposed structure.

Table 3 Requirements for a development process of sustainable solutions

Classification	Requirements
General requirements concerning the development process	Architecture of development process should be unitary and hierarchical (shows exactly which steps generate input or output for other steps) (Gill 2004)
	Configuration of the procedure (the procedure should be applicable for different companies and different branches) (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006; Gill 2004)
	Integration of external stakeholders (integration of customers as an external factor that can only be provided by the customer)(Tukker and Tischner 2006; Thomas et al. 2010)
	Provision of resources and capacities (The output of a PSS cannot be stored. Therefore, the development process has to take into account the needed capacities at a later stage.) (Thomas et al. 2010)
	Decoupling of development steps (leads to a high transparency and a high acceptance within the involved participants) (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Documentation of individual related know-how (This helps to conserve knowledge within the company.) (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Ensure the application-oriented development (a transparent connection between the development steps and the practical benefit afterwards (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)

(continued)

Table 3 (continued)

Classification	Requirements
	Supporting the communication within the development process. (Communication between interdisciplinary experts contributes solving complex tasks.) (Gill 2004; Tukker and Tischner 2006)
	Minimising of interfaces and components (reduction of complexity) (Gill 2004; NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Consider the principles of integration and parallelisation (Resources and human capacities are limited.) (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Unbundling of problems to smaller subproblems or whole system design approach (The solution of the smaller subproblems represents a holistic solution of the complex problems.) (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006; Gill 2004)
	Enhance development steps with methods and tool (Methods should be allocated clearly to different development steps.)
	Visualisation of theoretical concepts (Gill 2004)
Requirements concerning the development process in terms of a sustainable output and life cycle management	Consider all phases of the life cycle (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Realise the constitutive characteristics of services (Special characteristics of services and solutions must be considered.) (Gill 2004; NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006; Tukker and Tischner 2006; Belz et al. 1997)
	Estimate the technical, ecological, environmental and social aspects during the development process (During the development process, an estimation of the four criteria is necessary to rate the success of the solution.)(NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Consider a concept and construction of the solution (The development process needs steps which consider different concepts and construction aspects.) (Tukker and Tischner 2006; Thomas et al. 2010)
	Provide adequate documentation of the development process (A learning effect can be established.) (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Create a wide and transparent value network should be implemented (Tukker and Tischner 2006; NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Define criteria for the redemption of solutions (Tukker and Tischner 2006; NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)

(continued)

Table 3 (continued)

Classification	Requirements
	Establish training concepts and documentation to avoid inappropriate handling of the products (Aspects of life cycle sustainability have to be communicated directly.) (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)
	Have a clear understanding of the customers' cultural context and regulatory requirements (Tukker and Tischner 2006)

7 Conclusion

This chapter shows that many different aspects and requirements have to be considered when a sustainable solution should be developed. Tables 2 and 3 give the summary of different requirements. Based on the research, plenty of different requirements could be identified. The spectrum of requirements is very broad so that consciously no detailed structure of these requirements is introduced. However, the requirements are separated in requirements for sustainable solutions and in requirements which can be derived from these requirements concerning the development process. Furthermore, general requirements are identified which are dealing with the structure, the architecture, the communication and the visualisation for instance.

In the following chapter, existing approaches on development methodologies are analysed and checked against the collected requirements.

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State of the Art Regarding Existing Approaches

Christian Grefrath, Dirk Wagner and Sebastian Stermann

1 Introduction

The purpose of this chapter is to collect information on current methodologies of innovation (management) and solution engineering and to compare them against the requirements identified in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development".

In this chapter, existing methodologies supporting innovation and solution engineering are studied based on a life cycle view presented in Fig. 1. The life cycle description aims to combine the aspects related to strategy development and issues related to the life cycle management of the product and solutions that a manufacturing network is producing. For the sake of clarity, the life cycle is presented as linear in Fig. 1, although in practice the life cycle of one product is at least partly circular. The five stages presented in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development" have been complemented with business strategy development and innovation management phase (see Fig. 1).

In practice, life cycle phases are intertwined to each other and thereby development methods as well as requirements are also linked to each other. For instance,

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Fig. 1 Life cycle definition used as a baseline of this chapter

Fig. 2 Phase one of the life cycle model

Aurich et al. (2007) have described the product service system engineering process as life cycle management (LCM) that includes two product life cycles—manufacturers and customers. In the following sections, individual methodologies are discussed, although many of them consider several life cycle phases.

Individual methodologies which belong to one life cycle phase are discussed in the following subsections. This is just a general approach because many methodologies consider several life cycle phases.

1.1 Business Strategy Development and Innovation Management

Current management paradigms emphasise innovativeness, flexibility and agility. To be successful in an ever-changing networked business environment, companies must be proactive and innovative as well as operationally efficient (Gupta 2010). Innovation management and business development (see Fig. 2) are key elements in sustainability.

Today, companies' perceptions about sustainability are already changing. As in the past, company representatives see the potential for supporting corporate reputation, but recently, they have also come to expect operational and growth-orientated benefits in cutting costs and pursuing opportunities provided by new markets and products (Bonini and Gorner 2011). It has been even argued that there is a currently growing market for sustainability and that companies are already using sustainability to gain a position over competitors (Nidumolu et al. 2009). Thus, sustainability must be aligned also to other strategic targets of an individual company as well as targets of its network partners. If the customers are requiring sustainability and consider it critical, the companies must respond to this requirement in order to continue to compete. Furthermore, to be on top, companies must find new ways to implement sustainable development practices.

The Sect. 4 in Chap. "Requirements for Sustainable Solutions Development" does not directly form requirements for business strategy or innovation management. Still, the management paradigms are dealt with here because they form a basis for sustainable development and must therefore be considered. Because companies must be proactive and innovative as well as operationally efficient, several viewpoints regarding sustainable development must be considered and linked to strategic decisions.

1.1.1 Methods Used in Strategy Development

As mentioned before, business modelling process is overlapping with strategy development, because a business model provides a link between the strategy and operations and enables exploitation of entrepreneurial opportunities. Thus, related to the business modelling process, there are several existing methods, which can be utilised also in strategy development, for example, scenario building SWOT (Tukker and Tischner 2006), sustainability SWOT and (value) network or stakeholder analyses.

1.1.2 Methods Used in Innovation Management

Similarly to strategy development also innovation management methods are overlapping with tools supporting business modelling process. These are, for instance, *scenario analyses* and *PESTEL analysis* (political, economic, social, technological, ecological and legal). *Forecasting, backcasting, roadmapping, sign posting and customer observation* are examples of other methods which can be utilised also in innovation management and business development.

1.2 Management of Design, Planning and Development Phase

Most of product's costs are determined during its design phase (see Fig. 3). Thus, approaches regarding design and planning are important to sustainable

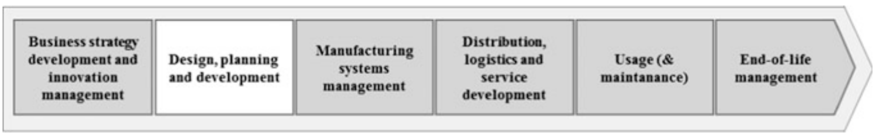

Fig. 3 Phase two of the life cycle model

development. However, sustainability of one product is always a limited consideration, because products are typically connected to each other, e.g. their production and use is a systemic phenomenon. Approaches of systems engineering, new product development (including product portfolio management), service development and "design for excellence" are covered here.

1.2.1 New Product Development

Portfolio management is about project prioritisation and resource allocation to achieve new product objectives for the company. It is a dynamic decision process where the list of active new products (offerings) and R&D projects (utilisation of capital and human resources) is constantly revised. One of the most referenced models for the management of the new product development projects is the stage-gate model introduced by Cooper (2000). The model proposes that product development projects are evaluated on the desired gates based on strategically important criteria.

As a very common structure of different development methodologies, "stage-gates" have been used in many development methodologies. This model subdivides the whole development process into different "stages" with set quality controls, the "gates", after each stage. The stage-gate model will be used here too as a basic conceptual model for the development methodology. Hence, the state-gate model will be described in more detail in Sect. 2 in Chap. "Development Methodology Solutions for Sustainable Solutions".

1.2.2 Systems Engineering

Systems engineering is an interdisciplinary field of engineering focusing on how complex engineering projects should be designed and managed over their life cycles. Issues such as logistics, the coordination of different teams and automatic control of machinery become more difficult when dealing with large, complex projects. Systems engineering deals with work processes and tools to manage risks on such projects, and it overlaps with both technical and human-centred disciplines such as control engineering, industrial engineering, organisational studies and project management (Haskins 2007).

1.2.3 Design for Excellence (DfX) and Design for Sustainability (D4S)

Traditionally, design for excellence (DfX) includes many forms of value, such as design for manufacturing, reliability and safety. Currently, also design for sustainability (D4S) is one of the globally recognised ways, how companies work to improve efficiency, product quality and market opportunities (local and export), while simultaneously improving environmental performance. Design for sustainability or D4S is also known as sustainable product design, and it includes the more

Table 1 Comparison of requirements for design, planning and development and current methodologies

Requirements defined in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development"	Systems engineering	Product and service development	Design for sustainability
Requirements concerning complexity management, modularisation	○		
Requirements concerning configuration principles	●		
Requirements concerning design, construction, durability, in particular how the environmental, customer and social requirements can be aligned with the company's interest and economic expectations		○	●
Requirements concerning costs and benefits as well as added value		●	
Requirements concerning environmental impacts			●
Requirements concerning (innovations and) technology		●	
Requirements concerning human rights, cultures and occupational safety			●

● Fully accomplished requirement; ○ partly accomplished requirement

limited concept of ecodesign (see http://www.d4s-de.org/). The D4S guidelines state that in developed economies, these efforts should be linked to wider concepts such as product–service mixes, systems innovation and other life cycle thinking approaches. Thus, the concept of D4S embraces best how to meet consumer needs—social, economic and environmental—on a systematic way. Both incremental innovation regarding current products and product innovation regarding new product development are included.

The following Table 1 summarises the main contribution of each methodology regarding the requirements defined in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development".

1.3 *Management of Manufacturing Systems*

This chapter deals with the different principles regarding the arrangement of manufacturing systems (see Fig. 4).

Fig. 4 Phase three of the life cycle model

One of the key concepts regarding the manufacturing phase is “sustainable manufacturing”, although also many other manufacturing principles have a strong connection to sustainability. Hereinafter, some key concepts are presented. Those are, for instance, sustainable and green manufacturing (or green supply chains). They are often used as synonymous, although some differences can be found within them. Green manufacturing focuses on environmental issues, whereas sustainable manufacturing highlights innovativeness and even new business opportunities offered by sustainability (Jawahir 2008). Thus, the concept as well as sustainability thinking in whole is work in progress. It can be hypothesised sustainable manufacturing would create greatest shareholder value (Jayal et al. 2010). This is a robust hypothesis, which can be either wrong or right depending on level or time of analyses. In the following, the manufacturing principles are covered in a chronological order starting from the most traditional manufacturing approaches. The approaches will be compared to the requirements which have been identified before.

1.3.1 Traditional Manufacturing

In this section, mass production, prefabrication and just-in-time (JIT) production are considered methodologies supporting the traditional manufacturing paradigm.

Mass production (also flow production, repetitive flow production, series production or serial production) is the production of large amounts of standardised products, including and especially on assembly lines. Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site and transporting complete assemblies or subassemblies to the construction site where the structure is to be located. Just-in-time (JIT) is a production strategy that strives to improve a business return on investment by reducing in-process inventory and associated carrying costs. Just-in-time production method is also called the Toyota Production System. To meet JIT objectives, the process relies on signals between different points in the process, which tell the production when to make the next part.

1.3.2 Lean Manufacturing

Lean manufacturing is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, “value” is defined as any action or process that a customer would be willing to pay for. Thus, lean manufacturing focuses on manufacturing phase and does not consider other life cycle phases (design, use, end of life).

1.3.3 Sustainable and Green Manufacturing

Green manufacturing focuses on environmental issues, whereas sustainable manufacturing highlights innovativeness and even new business opportunities offered by sustainability (Jawahir 2008). International Trade Administration (2007) defines sustainable manufacturing as follows: design and manufacture of high-quality/performance products with improved/enhanced functionality using energy-efficient, toxic-free, hazardless, safe and secure technologies and manufacturing methods utilising optimal resources and energy by producing minimum wastes and emissions, and providing maximum recovery, recyclability, reusability, remanufacturability, with redesign features, and all aimed at enhanced societal benefits and economic impact. On the other hand, sustainable manufacturing is defined as the ability to smartly use natural resources for manufacturing by creating products and solutions via a network of suppliers, partners and collaborators that due to new technologies, regulatory measures and coherent social behaviour are able to satisfy sustainability—economical, environmental and social objectives, thus, preserving the environment, while continuing to improve the quality of human life and remaining financially viable for the long term by returning adequate profits and growth (developed from (Garetti and Taisch 2012). This definition of sustain value project aims to highlight the system thinking and holistic view to sustainability, e.g. how value networks actors can create sustainability together.

1.4 Methodologies Regarding Ethical Sourcing, Trade and Consumerism

"Ethical sourcing" means ensuring that the products being sourced are created in safe facilities by workers who are treated well and paid fair wages to work legal. The ethical sourcing module is also a voluntary supplement for SQF 1000 or SQF 2000 Certified Suppliers.

Also other concepts, such as ethical trading, fair trade and ethical consumer, highlight social issues and global moral within decision-making. Still, as the concepts aim to influence on decision-making of individuals, they are connected also to product use phase. On the other hand, due to various political attributes, it can be stated that they are connected also to the design and development phase. The Ethical Trading Initiative is an alliance of companies, trade unions and voluntary organisations, who work in partnership to improve the working lives of poor and vulnerable people across the globe, whereas ethical consumerism is a type of consumer activism practised through "positive buying" in that ethical products are favoured, or "moral boycott", that is negative purchasing and company-based purchasing. Still, these concepts are often criticised from their Western country or brand owner origins; e.g., the programmes reach only limited number of producers

Table 2 Comparison of requirements for management of manufacturing systems and current methodologies

Requirements defined in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development"	Manufacturing methodologies	Sourcing methodologies
Requirements concerning business relationships	○	●
Requirements concerning transparency of used components and goods	●	●
Requirements concerning the manufacturing of the solution	●	
Requirements concerning the value network	○	○

● Fully accomplished requirement; ○ partly accomplished requirement

or do not sufficiently consider long-term impacts to local environment in developing countries.

All principles have some overlapping approaches to sustainability. First, different manufacturing principles have been evolved during several decades—each of them highlights different aspects, such as agility, flexibility, efficiency or innovativeness of manufacturing operations. Thus, their connection to sustainability is strongly linked to the economic dimension. Secondly, ethical sourcing and trading approaches focus on the social dimension of sustainability. In Table 2, the requirements for management and manufacturing systems are compared with current methodologies.

1.5 Management of Distribution, Logistics and Services

This section considers the sustainability aspects within present methodologies related to distribution, logistics and services (see Fig. 5).

1.5.1 Green Logistics

Logistics is the integrated management of all the activities required to move products through the supply chain, from raw material to end products. Some examples of green logistics include shipping products together, rather than in

Fig. 5 Phase four of the life cycle model

smaller batches; using alternative fuel vehicles for manufacturing and shipping; reducing overall packaging; utilising raw products which are harvested in a sustainable way; building facilities for manufacturing and storage which are environmentally friendly; and promoting recycling and reuse programmes. Similar means are identified also within green distribution.

1.5.2 Reverse Logistics

The concept of reverse logistics has also been introduced within the discussion sustainability of logistics industry. It stands for all operations related to the reuse of products and materials. Reverse logistics stands the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics, and thereby, it has a clear connection to the concepts of 3R's (Reduce, Reuse, Recycle) and 6R's (Reduce, Rethink, Refuse, Recycle, Reuse, Repair) discussed in the end of life cycle phase of the report. Thus, there is also a connection between reverse logistics and customer retention. Reverse logistics has become an important component within service business development, aiming at retaining customers by bundling even more coordination of a company's service data together to achieve greater efficiency in its operations.

1.5.3 Service Operations

Service involves a provider and a customer working together to create value. Accordingly, service systems can be defined as dynamic configurations of people, technologies, organisations and information that create and deliver value to customers, providers and other stakeholders. Within the manufacturing industry, the trend of customers, lead producers and their suppliers seems to be a forward transfer in their value chains. This means that customers and lead producers outsource manufacturing and their suppliers try to increase services. Suppliers provide not only raw materials and finished products, but also transportation, energy, packaging, design and recycling services.

In the following Table 3, the aforementioned methodologies are compared with the requirements presented in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development".

1.6 Management of Usage Phase

All the requirements related to the usage phase (see Fig. 6) should be considered already in the design and planning phase, where most of product (and life cycle) costs are defined. Similarly, the requirements of usage are also relevant within

Table 3 Comparison of requirements for distribution, logistics, services and current methodologies

Requirements defined in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development"	Distribution and logistics	Services
Requirements concerning training (education) and assistance		●
Requirements concerning suitable services (monitoring, inspections, consultancy, ICT solutions, etc.)		●
Requirements concerning delivery chain/networks	●	○

● Fully accomplished requirement; ○ partly accomplished requirement

Fig. 6 Phase five of the life cycle model

manufacturing phase regarding the usage of manufacturing equipment, and they are often considered also in manufacturing and maintenance methodologies.

1.6.1 Quality, Safety, Health and Environmental Management (QSHE)

As pointed out in above sections and illustrated in before, there are several management trends with overlapping concepts evolving together. Each of these management trends has their own traditions, and their modern versions also include sustainability aspects; for instance, safety management is closely linked to social and environmental dimensions of sustainability, while environmental management is clearly connected to the environmental dimension. Their focus is typically on management practices of an individual company. Spreading of quality management methods started from using statistical methods for quality control for production. Later on, a number of highly successful quality initiatives have been invented by the Japanese (for example, Genichi Taguchi, QFD, Toyota Production System). Certification according to quality as well as environmental standards is nowadays quite essential, and thereby, many quality management tools, such as Six Sigma, are utilised in companies. Furthermore, emerging management disciplines (like system thinking) are bringing more holistic approaches also to quality so that people, process and products are considered together rather than independent factors in quality management.

1.6.2 Maintenance During Usage Phase

Maintenance involves maintaining and securing the equipment and systems in, or restoring them to, a state in which they can perform the required functions. The challenge for maintenance planning is to identify appropriate objects and tasks for preventive maintenance and ensure that there are adequate resources for the repair actions (Rosqvist et al. 2009). In the literature, there are presented several maintenance programme planning methodologies. Those approaches are standard reliability-centred maintenance (RCM), business-centred maintenance, Waeyenberger and Pintelon approach and value-driven Maintenance.

1.6.3 Performance Management

Performance management is defined as the process of analysing performance-related information (generated through *performance measurement*); making decisions based on this information, planning and implementing actions to improve or maintain the state of performance; and feeding back information intended to improve the process of performance measurement. Furthermore, in order to be able to generate the information that is necessary for informed decision-making, knowledge of influencing factors on performance as well as causal relations between influencing factors and performance characteristics has to be known. Thus, organisational performance is complex and can be affected by a host of different factors.

In the following Table 4, their main contribution, in what sense known management methodologies of usage phase are supporting sustainable decision-making, is evaluated.

Table 4 Comparison of requirements for usage phase and current methodologies

Requirements defined in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development"	QSHE management	Maintenance and asset management	Performance management
Requirements concerning consumption of energy, water, materials, air, land	●		○
Requirements concerning emissions and waste	●		○
Requirements concerning efficiency and intensity of usage, maintenance		●	○
Requirement concerning the continuous improvement	●	●	○
Requirements concerning safety and health	●	●	○

● Fully accomplished requirement; ○ partly accomplished requirement

Fig. 7 Phase six of the life cycle model

1.7 End of Life Cycle Management

This section considers the present methodologies regarding the end of life cycle management (see Fig. 7). Thus, the concepts related to this phase (for instance, 3R's and 6R's) emphasise the circular nature of life cycles.

1.7.1 Reverse Logistics

Reverse logistics stands for all operations related to the reuse of products and materials. It is "the process of planning, implementing and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. More precisely, reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics" (Hawks 2006).

1.7.2 From 3R'S to 6R'S

The 3R's (Reduce, Reuse, Recycle) are described as starting point of sustainability implementation programmes. The principles are the following: (1) Reduction: purchasing and using only what is necessary, (2) Reuse: find an alternative use extra materials and (3) Recycling: unused materials are transformed into new products. The focus of 3R's is clearly on environmental efficiency, although implementation of main principles (3R's) also can increase company's profitability.

In the following Table 5, their main contribution, in what sense known end of life cycle management methodologies are supporting sustainable decision-making, is evaluated.

Table 5 Comparison of requirements for end of life cycle and current methodologies

Requirements defined in Sect. 4 in Chap. "Requirements for Sustainable Solutions Development"	Reverse logistics	3R's & 6R's
Requirements concerning recyclability and reusage	●	●

● Fully accomplished requirement; ○ partly accomplished requirement

2 Gap Analysis of Existing Development Methodologies Considering Sustainability

The previous sections considered several methodologies related to industrial management in order to collect information on how they could support innovation management and solution engineering towards sustainable solutions within manufacturing networks. As pointed out before, these management paradigms have overlapping concepts and are all the time evolving together. Although there is a consensus on the importance of networks, most of the management methods still focus on individual organisations.

In the following, gaps of current methodologies are analysed based on Tables 1, 2, 3, 4 and 5:

- Methodologies in *business strategy and innovation management*:
  There are only few tools that clearly link sustainable development to strategic decisions and innovations, e.g. how sustainability can offer competitive advantage, differentiation and new business opportunities
- Methodologies in *design, planning and development*:
  The existing tools focus typically on how to ensure that strategic targets are considered during the new product (or service) development work, rather than setting the strategy, especially with focus on sustainability.
- Methodologies in *manufacturing systems development*:
  The current approaches do not cover network and life cycle aspects, although holistic thinking and integrated approaches are required.
- Methodologies in *distribution, logistics and services*:
  Similarly to manufacturing approaches, the focus has been on individual company, while service thinking highlights that collaboration with customers should be covered.
- Methodologies in *operation and maintenance phase*:
  Modern versions of management methodologies within operation and maintenance phase include also sustainability aspects, but once again the focus is on individual company.
- Methodologies in *end of life cycle*:
  Broader approaches (3R & 6R) already exist, and still network and strategic approaches within them are missing.

3 Conclusion

Existing methodologies could be used in order to support innovation management and solution engineering within the manufacturing industry—also from the sustainability perspective. All the presented methodologies are considering at least some of elements of sustainable development (see Tables 1, 2, 3, 4 and 5). Based on the gap analyses, we summarise that the present methods:

- focus on an individual company rather than a network and
- consider operational issues more than strategic thinking.

According to the gap analysis presented in Sect. 2, system boundaries must be broadened from an individual company to a value network level—and even to business ecosystem including also other stakeholders. The new methods should support actors defining what sustainability means to their solutions within their industry and to business (models) of all involved actors—both at value network and at ecosystem level. In the following chapter, the authors present a development methodology for sustainable solutions.

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Development Methodology for Sustainable Solutions

Christian Grefrath, Dirk Wagner, Marco Macchi, Maria Holgado Granados and Sebastian Stermann

1 Introduction

This chapter aims to develop a framework which enables companies to analyse and optimise their processes in order to increase their sustainability. Based on the methodological and scientific gaps that were identified in Sect. 2 in Chap. "State of the Art Regarding Existing Approaches", the authors offer a holistic concept by combining and integrating various management and operational methods and supportive tools.

The intended improvements cover all three dimensions of sustainability: on the one hand, improvements of processes might increase a company's productivity and efficiency and, thus, lead to economic sustainability. On the other hand, also social

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and environmental aspects of sustainability can be captured. Well-organised processes and conflict-free communication between divisions have the potential to tremendously improve employees' contentedness.

2 Conceptualisation of a Development Methodology for Sustainable Solutions

According to the gap analysis presented in Sect. 2 in Chap. "State of the Art Regarding Existing Approaches", system boundaries must be broadened from an individual company to a value network level, which covers the whole life cycle. The new methods should support actors defining what sustainability means to their solutions within their industry and to business (models) of all involved actors—and break those targets down to activities of each stakeholder that take place. To realise the development on a network level an interdisciplinary approach with interaction of all involved stakeholders during the development process has to be realised.

According to these conclusions, the development methodology for sustainable solutions should cover several phases of life cycle and the activities of the relevant stakeholders, here called dimensions. This approach is shown in Fig. 1.

The present methodologies support sustainable development at operational level, but the descriptions on how to set strategic objectives are partly missing. In other words, baseline for sustainable development should be strategic activities that integrate the central idea of sustainability—here called *central initiation*. Besides these strategic activities, procedures have to be defined to conceptualise sustainable solutions in terms of products, services or product-services systems—here called *conceptual dimensions*. To cover also activities of stakeholders, that act during the life cycle more operationally, and allow also sustainable innovation and development from their perspective, all planning activities have to be regarded in the Development Methodology for Sustainable Solutions—here called *operational dimensions*. These activities require a multilevel approach to sustainability, in order to understand the self-interests of involved actors and ensure their commitment.

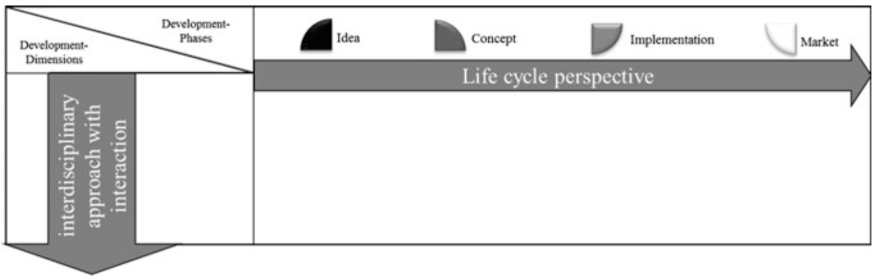

Fig. 1 Interdisciplinary approach over the whole life cycle

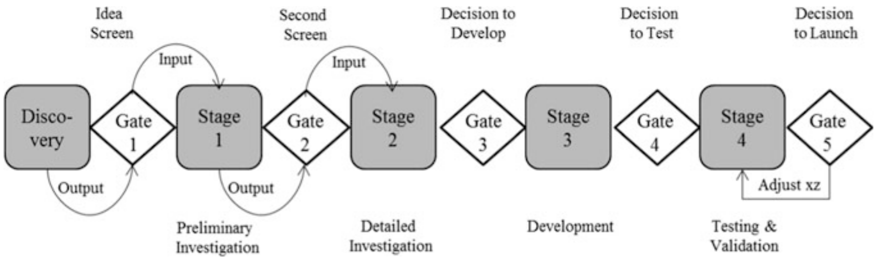

Fig. 2 Example state gate model for all development dimensions (adapted from Cooper 2000)

Each of those activities in the named dimensions will be described with stages and gates, according to the stage–gate model (Cooper 2000). The stages resemble the different "proof of design activities" which have to be executed in the whole development process. To guarantee the quality of the results of the development, methodology gates serve as check points within the process. Besides, these gates foster the integration and the interaction of all stakeholders, as they provide the operator of the methodology with guidance/checklists whether all important aspects to develop a sustainable solution and the perspective of all stakeholders have been considered. In the following, the important activities and tools for the development methodology are mentioned. Furthermore, responsibilities and interfaces to other stages and gates are highlighted. Consequently, the Development Methodology for Sustainable Solutions covers stages and gates for every development dimension (see as an example in Fig. 2).

The dimensions of the framework are listed below.

- Strategy development,
- Business model development,
- Technology development,
- Product-service system development,
- Product development,
- Service development,
- Sourcing planning,
- Manufacturing planning,
- Distribution and logistical planning,
- Service and spare parts operational planning,
- End-of-life and recycling planning.

For each dimension, well-established approaches have been identified and partly adjusted (see Sect. 1 in Chap. "State of the Art Regarding Existing Approaches"). The adjustment of each method has been quite different. Each method has been subdivided into single steps, each ending with a clear gate to check the result of the previous stage. Further, the methods have been improved towards their integration of the three aspects of sustainability. In several cases, sustainability is only partially or not at all integrated into the method. In this case, it has to be completed within this methodology for sustainable solutions.

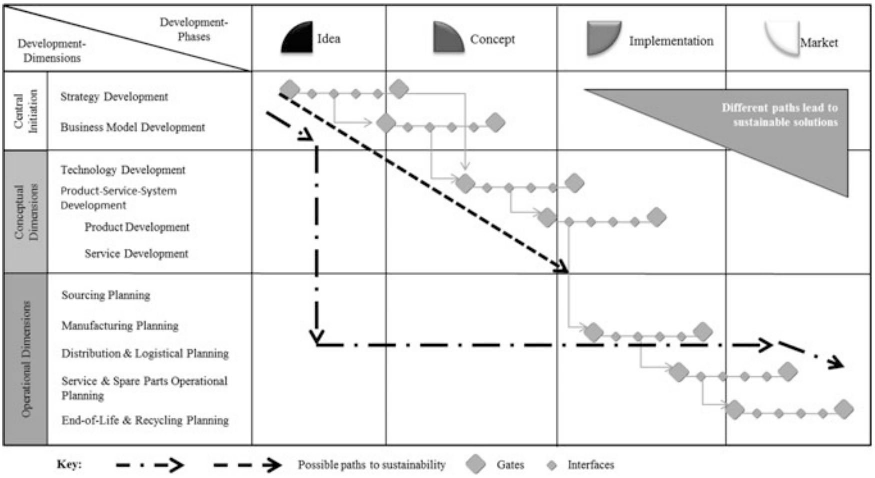

Fig. 3 Development framework for sustainable solutions

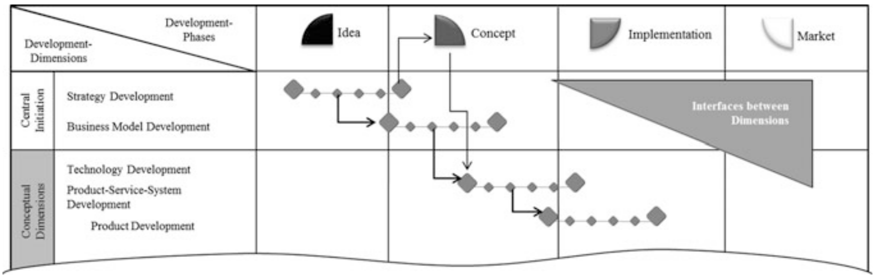

Fig. 4 Interfaces and gates between dimensions

3 General Development Framework

A sustainable solution may be a product, a service, a new operating practice, a new business model or a combination of any or all of these. So the assumption is that sustainability can be realised through changes in any business activities. The suggested Development Methodology for Sustainable Solutions tries to give a framework for different paths to sustainability, without having a strict step by step approach that has to be executed by the company or the value network (see Fig. 3). The main innovation of this all-embracing methodology is to emphasise all important connections and interfaces between the different methods. By subdividing each method into specific stages and gates, it is possible to find existing interfaces or to define new necessary interfaces for an improved cooperation and thereby reaching a higher degree of sustainability.

An interdisciplinary approach of a solution development process is able to reach a new level of sustainability by a clear, open, well-organised and well-described cooperation of all participating stakeholders, acting in different dimensions.

In the next section, the conceptualised dimensions of the framework will be described in detail, showing the interfaces between all the methods to be able to develop sustainable solutions (Fig. 4).

4 Development Methodology for Sustainable Solutions

The following section enhances the framework which is introduced in Sect. 2 with detailed content regarding different methodologies, tools and interfaces of the different dimensions. The sections are structured in the same way as the dimensions of the framework. The content of every stage/gate is presented and adequate tools are introduced. Furthermore references to responsibilities and interfaces are given. Figure 4 shows different interfaces (small buttons) and gates (big buttons) within the framework. The tools which are mentioned are going to be described in detail in the upcoming sections.

4.1 Methods—Central Initiation

Strategy Development

Strategies exist at several levels in any organisation—ranging from the overall business (or group of businesses) through different operations and organisation levels to individuals working in it. Corporate strategy is concerned with the overall purpose and scope of the business to meet stakeholder expectations. Strategic analysis, strategy development (choices) and strategy implementation are the key elements of a strategic management process. In an academic discussion, at least four views of strategy development processes can be distinguished. They are rational planning, planning as a guided learning process, planning on the basis of logical incrementalism and emergent strategy formation (Idenburg 1993). Strategic analysis is about analysing the strength of businesses' position and understanding the important external and internal factors that may influence that position. Strategy development involves understanding the nature of stakeholder expectations (the "ground rules"), identifying strategic options, and then evaluating and selecting strategic options. Strategy implementation typically is the hardest part. Implementing a strategy may require organisational, operational or business model changes such as creating new units, merging existing ones, new operations or division of work or even changing offerings, developing new products or services and modifying the earning logic. Therefore, it is important that many internal communication channels exist between different divisions within a company.

The next section goes through the three stages of general strategy process: (1) strategic analyses, (2) strategy development and (3) strategy implementation, the appropriate tools for each stage, and the gates in which the results of the stage in question are analysed.

Stage 1: Strategic Analysis

The strategic analysis stage targets to identify through structured analysis both the external and internal drivers. It provides important input, and it is strongly linked to the first stage of business modelling process. The tools appropriate for this stage should support participants in defining the business purpose, industry-related requirements, norms and opportunities including the firm position to sustainability (current and future) and its drivers. *Corporate Sustainability Continuum, System SWOT and PESTLE and STEEPLED* were identified as tools supporting first stage of business modelling process.

Gate 1

To pass through the gate 1, it has to be decided whether the strategy group has enough knowledge to bring out the vision and can go further to strategy development.

Stage 2: Strategy Development

The second stage, strategy development, is guided by the vision and defines the strategic choices. Also within this stage, the link to business modelling process is strong, e.g. *sustainable business model archetypes and scenario analyses* can be utilised to illustrate different options regarding sustainability. Furthermore, business model concretises these strategic choices by defining customers, offering, key resources, value network and earning logic.

Gate 2

Within this gate, the participants of strategy development stage should be able to illustrate the strategic choices to the whole organisation. The gate can be passed when it is defined where and how the organisation will compete and cooperate.

Stage 3: Strategy Implementation

Strategy implementation stage is the translation of chosen strategy into organisational actions so as to achieve strategic goals and objectives. Many methods and approaches related to this organising stage are originally change management tools and thereby vision, mission and values of the organisation are brought to guide the strategy implementation. In this stage, tools *such as strategic portfolio management, balanced scorecard and KPIs* can be used.

Gate 3

Strategy implementation should be a two-way process where it is possible to change the strategy also through a bottom-up approach. The gate can be passed when interfaces and communication channels within the company and with external stakeholders are defined.

Business Model Development

This section will elaborate on the process and a portfolio of tools and methods that assist in the design of sustainable business model/s. The process and toolset will support and be part of the idea and conception phases of the development framework for sustainable solutions, while being aligned with strategy development. Sustainable business modelling consists of five steps and each step is accompanied by a selection of tools that will assist firms in understanding and delivering sustainability. The objective is to assist companies in developing future-oriented and novel forms of business that will deliver sustainability through a clearly defined sustainable business modelling process whilst adapting to the requirements for sustainability. The tools have been identified or specifically designed to focus on generating business model innovation for sustainability from a system perspective. The toolset includes tools and methods that assist in developing and transforming the new sustainable value proposition.

Stage 1: Purpose of the Business

This stage is about 'setting the scene'. It involves developing an understanding of the rationale of the business along with its values and sustainability, whilst identifying the company's position and drivers for engaging in sustainability along with anticipated threats and opportunities for environmental and social sustainability. The tools that assist in this stage are *System SWOT analysis*, *PESTLE/STEEPLED* and *sustainability continuum* including an introductory presentation on the process and where necessary, a brief overview of sustainability.

Gate 1

To pass through this gate, the identification of the company's business purpose, drivers and its progress/path towards sustainability has to be determined.

Stage 2: Identify Potential Stakeholders and Select Sustainability Factors/ Priorities

This stage is about identifying the stakeholders in the industrial network and sustainability priorities that will assist in exploring the new sustainable value proposition. The purpose of the organisation and understanding of sustainability and target position for the future from the previous stage helps towards determining sustainability priorities. The tools that will assist in this stage are the *value mapping tool, scenario management tool, Global Reporting Initiative Guidelines* (GRI guidelines) and *industry specific Sustainability Accounting Standards Board* (SASB).

Gate 2

This gate can be passed when a set of stakeholders and sustainability priorities are selected for the next stage.

Stage 3: Explore and Develop new Opportunities for Sustainable Value Proposition

This stage is about generating a new sustainable value proposition/s towards designing a sustainable business model with a focus on the industrial network. It is concerned with understanding and analysing various forms of value across the network to develop the new sustainable value proposition. Useful tools are the *scenario management* and *value mapping tool*.

Gate 3

To pass through this gate, a presentation of new sustainable value proposition or a selection of propositions has to be considered.

Stage 4: Concept Generation and Selection

This stage involves the selection of one or a combination of feasible business models, concepts or solutions for the transformation of the new sustainable value proposition or propositions (stage 3) so as to seek ways/paths to capture opportunities for value creation, whilst minimising negative value and maximising positive value in the network. The tools that will assist at this stage are the *sustainable business model element archetypes typology* and *sustainability impact calculation tool*.

Gate 4

To pass this gate, a decision on an archetype/solution or a combination of archetypes has to be opted.

Stage 5: Define and Develop the Value Creation and Delivery System, and the Value Capture Mechanism

Stage 5 includes the identification and potential development of the value delivery and capture system (key activities, channels, resources) whilst analysing the cost incurred through the life cycle to assist in evaluating the options. This stage builds on steps 2 and 3 on the understanding of stakeholder value and value exchanges in the network. The tools that will assist this stage are Osterwalder and Pigneur (Osterwalder and Pigneur 2010) *business model canvas* and *the life cycle cost (LCC) estimation tool* (developed in WP3 by ELCON and VTT). The business model canvas supports in the coordination and configuration of the key activities, resources, partners and channels and the value exchanges and value capture between stakeholders in the network.

Gate 5

To pass through this gate, the mechanism for the value creation, delivery system and value capture has to be determined.

4.2 Methods—Conceptual Dimensions

Technology Development

Technology management includes several managerial disciplines that enable organisations to manage their technological knowledge in the creation of competitive advantage. There are several methods used in technology management such as technology strategy development (role of technology in organisation), technology forecasting (identification of possible relevant technologies), technology road mapping (mapping technologies against business and market needs), technology project portfolio (what projects are under development) and technology portfolio (what technologies are in use).

Sahlman (Sahlman 2010), for instance, is suggesting that enterprises should consider defining and developing the necessary structures and objectives for strategic technology management to proactively manage impacts of technology for competitiveness of the enterprise and for sustainable development of its socioeconomic environment. There are multiple theoretical as well as practical frameworks for defining elements of technology management (for summary, see, e.g. (Sahlman and Haapsalo 2011).

Stage 1: Define the Requirements for New Technology

In this stage, the corporate management group defines needs and requirements of the new technology based on the strategic work. The tools appropriate for this stage should support participants in defining the business purpose, industry-related requirements, norms and opportunities including the firm position to sustainability (current and future) and its drivers. Therefore, *Porter´s five forces* analysis and *road mapping* are useful tools.

Gate 1

As an output of the first stage of technology development process, a specification of new required technology should be available. The strategic alignment of this specification has to be evaluated before the decision of moving towards the second stage can be taken.

Stage 2: Evaluate Your Own Technology Portfolio and Your Own Capabilities to Develop the Required Technology

At this stage, managers of different technology disciplines (e.g. mechanical, automation, hydraulics and electricity) should cooperate in order to increase cross-functional knowledge in an organisation in the early phase of the development activities. If suitable technology could be identified during the portfolio evaluation managers of an organisation are already capable to judge the readiness to move on to other processes (PSS, service or product development processes). If suitable technologies are not available in the organisation, the capabilities of organisation should be evaluated and issues such as whether they are competitive enough to conduct the activities related to new technology development should be taken up.

Gate 2

To pass through this gate, a decision needs to be taken on whether it is possible to use current technology in new application and move on to other development processes.

Stage 3: Search Suitable Technologies from Outside

Search new technologies from outside. Technology searching activities could be conducted simultaneously with the portfolio evaluation. The methods related to searching of new technology could include, e.g. *competitor and network analysis*, *patent database studies* and other business intelligence activities.

Gate 3

The technology search should produce further information to decision-making on what is the most feasible way to develop the required technology.

Product-Service System Development

The effect of standardised development methods is useful to reduce development costs, development time and improve the quality of produced goods or services (Bullinger and Scheer 2006). Therefore, it is important to create clearly defined standards to develop an even more complex product-service system. For the development of product-service systems, various approaches already exist. Nonetheless, most of them do not focus on sustainability with its three different perspectives: economic, social and environmental sustainability. Although most of these approaches integrate them slightly, they do not sufficiently concentrate on sustainability.

Stages and Gates

Tukker and Tischner (2006) discovered that the main process of PSS development can be roughly subdivided into three main steps, considering the analysed PSS development approaches. The identified steps are the analysis-phase, the creation-phase and, thirdly, the implementation and realisation-phase.

Stage 1: Preparation and Introduction

In the stage of Preparation and Introduction, a general plan of the development project and an appropriate project team is to be set up. After forming the project team consisting of various experts, the team members need to be familiarised with the idea of a product-service system concept. For a further stakeholder analysis, the stakeholder value mapping tool can be used. Here, every value can be illustrated for every stakeholder to get an easy overview of changes for each stakeholder.

Gate 1

In gate 1, it has to be checked whether the team really consists of all necessary experts concerning the planned PSS.

Stage 2: Analysis on PSS Opportunities

The first step in stage 2 is to select areas with priority needs. Therefore, the project team has to investigate which need areas or markets in general come into question. Afterwards, they have to prioritise these markets to detect the most interesting ones, where they might carry out the PSS project (e.g. by priority setting matrix). Furthermore, the own existing PSS of the company is to analyse regarding possible opportunities towards a new PSS for the company. Here, the Strategy and Business Model Development has to be included to guarantee that the PSS fits into the general business model of the company. Regarding possible opportunities, threads, etc., of a PSS, the project team is to use a *SWOT analysis*. Another important tool is the *scenario analysis*. As a next step, the project team has to analyse the needs of their possible clients. For this purpose, it defines relevant market segments and underlying client needs for the selected areas. This may be done by simple but *persistent questioning approaches*. The next substep is to draft a system map of the current system that is to be improved or changed by the new PSS.

Gate 2

The project team has to decide, based on what they investigated and found out before, whether the PSS is actually interesting for the company and sufficiently sustainable in all three aforementioned aspects of sustainability.

Stage 3: PSS Idea Generation

The project team's next task is to generate ideas for the possible new PSS. Using the information of the previous stage, i.e. client needs and the results of the SWOT analysis, the idea generation could start e.g. by different creativity tools. These might be, for instance, *brainstorming, brainwriting*, etc., whilst creating possible ideas, sustainability guidelines (SustainValue 2012) should be used permanently. The complete set of new ideas is now to be described systematically within an idea description sheet and checked against sustainability requirements for sustainable solutions.

Gate 3

Firstly, in gate 3, it is important that the project manager controls the completeness check conducted in stage 3. Additionally, the project manager has to check whether and to what extend the aspect of sustainability is included within the new idea.

Stage 4: PSS Concept and Design

In stage 4, the project team works on the PSS design and structure. An essential aspect of the PSS structure is the examination of interactions and interdependences of all concerned actors. In addition, an evaluation of different system components and whether they match is a main aim. Tools as *service blueprint or FMEA* could be used to support the PSS development. As a next step, a make-or-buy decision has to be made. It is important to include surrogates of the dimensions of Sourcing

Planning and Manufacturing Planning to include their valuable expertise in the field of sourcing and production

Gate 4

The project team has to decide whether to implement the system, to go back to the idea of the beginning of the design stage or to cancel this idea at all.

Stage 5: PSS Implementation Plan

In the final stage of the PSS development, the PSS implementation plan is to be defined. Therefore, the project team defines a list of implementation issues, e.g., within a workshop. Implementation issues might closely correlate with the results of the SWOT analysis in stage 3, the stage of idea generation. Once these issues are defined and completed, the project manager has to produce a management report to introduce the PSS and its possible implementation. In order to support the implementation plan, *the Sustainable Impact Calculation Tool* is recommended to use.

Gate 5

At gate 5, the project manager has to make sure that the implementation plan is complete, consistent and accomplishable.

Product Development

Considering the different product development approaches, it gets clear that most of the existing ones do not fulfil the requirement of clear development steps including specific control gates. In addition, most approaches have no real focus on sustainability during the whole development process. Both the clear structure and the established position in industry of the product development model of Pahl and Beitz (2006) recommend the usage of their model in this development methodology. Important aspects considering sustainability within the development process have to be added. Pahl and Beitz created an overall product development process which can be used intersectorally due to its generality. They describe the two main parts of a product development process as the analysis and later on the synthesis phase. Their development approach is subdivided into the four main steps of the development and engineering process. These steps are "planning and clarification of task", "conceptual design", "development" and "elaboration of product documentation". Further, the section "Implementation and market launch" will be added.

Stage 1: Planning and Clarification of Task

At the beginning of a product development process, the general tasks have to be clarified by a product development team for the specific development process. The clarification of the tasks to be performed by the product serves a gathering of all information towards the detailed requirements of the product, their conditions and modalities as well as their specific meaning. The result of this clarification process should be a product specific requirement list. Furthermore, *scenario analysis* should be conducted.

Gate 1

The requirement list developed in stage 1 has to be checked towards completeness before the development process goes on to the concept stage.

Stage 2: Conceptual Design

Within the conceptual stage, the stage of planning and clarification of the task will be abstracted to its basic challenges and problems. Before starting the conceptual design, the project team has to clarify if a step by step approach really is necessary for this specific development project. Therefore, it is recommended to check if already known solutions may be a foundation for further concept and elaboration steps or if the whole concept phase might be unnecessary by these existing solutions.

Gate 2

To pass through this gate, the developed concept has to be checked due to its crucial importance for the whole development process. This can be done by screening all possible conceptual solutions and the evaluation process towards the determined concept.

Stage 3: Embodiment Design

Within the stage of embodiment design, the design of the previously generated concept is developed. The design will be developed in accordance to technical, economical and sustainability criteria. Therefore, it is important to include specific data considering the life cycle behaviour of previous and similar products. Here, the knowledge and experience of the service planning dimension must be included into the development process. During the stage of embodiment design, the product designers have to determine an overall layout design, a preliminary design of the form and the production process. In addition, they have to provide solutions for all auxiliary functions. The development takes place by using scale drawings, critically reviews as well as technical and economic evaluation.

Gate 3

To pass through this gate, the definitive layout has to be controlled by the project manager. It has to be checked against all embodiment-determining requirements (for main and auxiliary functions).

Stage 4: Detail Design and Elaboration of Product Documentation

The detail design stage contains the process to complete the embodiment of technical products. Therefore, final instructions considering shapes, forms, dimensions and properties of the surface will be implemented towards all single product components. Furthermore, the selection of materials is to be defined as well as the final scrutiny of underlying production methods, procedures and costs. Here, the dimensions of Sourcing Planning and Manufacturing Planning should be involved into the development activities. Another task of this stage is to elaborate the production documents including drawings of components and assemblies and related lists of all parts.

Gate 4

In gate 4, it is to control if all final instructions are fully implemented. Furthermore, the selection of the specific product materials as well as the production methods is to be checked considering all three aspects of sustainability (economic, social and environmental). Finally, all documents have to be checked for completeness and consistency.

Stage 5: Implementation and Market Launch

Although Pahl and Beitz (2006) do not include the step of product implementation and market launch it can be integrated into a full product development process. Due to the fact that this step already is described in detail within the section of product service system development a short reference to Sect. 4.2, stage 5 is sufficient.

Gate 5

The contents of stage 5 have to be checked by the project manager at first. He has to make sure that the implementation plan is complete, consistent and accomplishable. If it is not, he has to take care that appropriate improvements will be done.

Service Development

Towards the dimension of service development, different useful methods and approaches can be found. Both structure and extent of these development approaches vary enormously. Whereas some of them stop after the definition of the service idea (Sontow 2000), others include all phases up to the implementation of the new service and the following market phase. One of these methods is the FIR service engineering approach (DIN 2008, 1082:2008–05). Although all approaches do not have their focus on sustainability, or consider it at all, the FIR service engineering approach can be used for this development concept for sustainable solutions. Nonetheless, considering the topic of sustainability important aspects has to be included in this approach.

Stage 1: Activation and Definition

At the beginning of stage 1, the whole development process gets activated. It starts with the generation of possible ideas. The first idea generation can be supported by simple creativity tools as *brainstorming and brainwriting*. After generating ideas, possible customers have to be identified. Here as well, a market research could support the customer identification. In addition, the stakeholder value mapping tool (UC, cf. PSS development) can be integrated in this process. At the end of stage 1, appropriate objectives for each specific service development process have to be formulated. Thereby, it is important to integrate sustainability factors, e.g., by using sustainability guidelines.

Gate 1

The service management has to control if the new service idea fits into the existing portfolio of PSS, products and services. In addition, it is to check whether the new service idea is in accordance with the company strategy and its general business model.

Stage 2: Planning

At the beginning of this stage, a team of service experts has to do a detailed market research for the service idea found in stage 1 and create a provisional plan for the market launch at the end of the development process. Beside conventional market research tools, the stakeholder value mapping tool can as well be of interest to include all possible stakeholders affected by the new service idea. Furthermore, the responsible service experts have to do a detailed technical evaluation. Here, it is important to corporate closely with the department of Technology Development to check the technical sense and feasibility of the service. Using the tool of service blueprinting might be of help to get an overview of the needed infrastructure for the service introduction. Another tool that can be used for decision-making is systems dynamics: this would also be useful in order to plan and prepare the infrastructure. The next step in this stage is to create a sustainable business model around the new service concept. Therefore, the information towards the architecture, technical aspects and needed infrastructure of the service has to be used. In this context, the service experts have to create a requirements specification sheet. At the end of stage 2, a detailed development plan with a clear performance and requirements specification sheet as well as a business model for the new service have to be generated.

Gate 2

To pass through gate 2, different aspects regarding the plan of the new service idea have to be checked by the management of the service department. Beginning with the evaluation of the of the service idea based on the internal and external feedback, a clear decision has to be made if the service idea will reach the stage of concept and infrastructure development.

Stage 3: Development of Concept and Infrastructure

The first step in this stage is the development the service prototype and its technical introduction in first test runs. After this is done, the detailed resource planning can start. Now the rough and conceptual planning of stage 2 has to be concretised. Therefore, a close cooperation between the dimensions of service development, sourcing planning and as well the dimension of end-of-life and recycling planning has to be given. In addition, a detailed programme considering the market launch has to be developed. Therefore, different concepts need to be generated. These concepts are the sales, the marketing and the communications concept.

Gate 3

After the development and usage of the first service prototypes, a first practical economic efficiency analysis has to be conducted. Furthermore, the service management has to test the consistency of the service concept, infrastructure, sourcing, end-of-life, training programme, sustainability, etc.

Stage 4: Implementation

In stage 4, the new service will be converted to the pilot stadium. In this further testing phase, last gaps and weaknesses can be eliminated. After this is done the *service blueprint* can be finalised. Now it is possible to structure the new service in different modules as a basis for specific adaption towards customers' wishes.

Gate 4

To pass through gate 4, it has to be controlled if the new service is still cost effective or if previous changes altered things in that extend that sufficient cost-effectiveness is not given anymore.

Stage 5: Market Phase

At the beginning of the market phase, the service has to be further adapted to the customers wishes and requirements. Here, the cooperation between service technician and service experts has to be close to optimising the service in case of need.

Gate 5

In gate 5, there has to be a general control by the service management considering the service performance in the field.

4.3 Methods—Operational Dimensions

Sourcing Planning

The concept of strategic sourcing emphasises the link between strategic objectives and sourcing operations of a company—sourcing planning considers strategic sourcing decisions before the actual purchasing processes and supply chain management. Since materials, components and services purchased represent significant part of companies' sales in the present networked economy are ethical sourcing as well as green supply chain management principals utilised in many Western companies. In this section, sourcing planning has been divided into two main tasks. First at the strategic level, the main task is to set the targets to sourcing. Then at the operative level, the task is to search and evaluate possible suppliers. The first task considers the opportunities, objectives, and pay-offs between the choices related to sustainability within sourcing. Thereby, in accordance with strategy development, it aims to find answers to the "Why?" question. The second task is related to the operative "What?", e.g. the supplier searching and evaluation oriented activities of sourcing planning. Within this section, these two tasks are considered as two main stages of sourcing planning for sustainability.

Stage 1: Set the Strategic Targets to Sourcing

At the strategic level, the main stage of sourcing planning is to set the targets for sourcing. This stage considers the opportunities, objectives, and pay-offs between the options related to sustainability within sourcing. Different *portfolio analyses* have been typical tools of strategic sourcing and purchasing, since Kraljic (1983) presented his well-known purchasing portfolio. Based on this approach, Pagell et al. (2010) have presented the sustainable purchasing portfolio model. Furthermore, *portfolio management approach* presented in strategy development section can be utilised also within the strategic sourcing planning. The sustainability matrix could be utilised to evaluate the interests of various stakeholders and thus align the interests of all involved actors.

Gate 1

At the first gate, the managers of the company—both corporate and sourcing managers—have to define sustainability guidelines for sourcing. This means defining the importance of sustainability in sourcing decisions.

Stage 2: Search for and Evaluation of Possible Suppliers

At the operative level the main stage of sourcing planning is the search for and evaluation of possible suppliers (contract partners). Similarly to the first stage several different methods and tools can be utilised for this work. The two stages are also closely linked together, so strategic considerations related to sustainability principles of sourcing should guide the supplier search and evaluation process. The comparison between possible suppliers and supplier classifications are typically done based on different purchasing portfolio criteria. Two tools, which support especially supplier selection, are of great importance. Those are the *maturity model* and *the supplier evaluation matrix*.

Gate 2: Selection of Suppliers (contract partners)

To pass through this gate, the sourcing managers and purchasers have to select the contract partners from the possible suppliers based on the analyses and comparisons made at search and evaluation stage.

Manufacturing Planning

Manufacturing planning considers the long-term decisions with regard to the manufacturing system (re)configuration, and subsequent (re)organisation of resources. This is also variably referred to by means of other terms such as manufacturing system design, facilities planning, factory planning. On the whole, this process deals with all the decisions related to the long-term planning of an industrial plant where manufacturing operations are executed—both in the case a new plant is built from green field, and when the plant already exists and replanning is required for performance improvement. Further on, the manufacturing planning process typically covers many issues such as process technology and equipment selection, capacity planning and work load balancing, facility layout and material handling system design, etc. Indeed, many of these issues also matter to the manufacturing strategy (Hayes and Wheelwright 1984; Fine and Hax 1985; Leong et al. 1990; Miltenburg 2005), regarding a long-term perspective of operations in manufacturing facilities; amongst them, both process technology and production facilities, but also human resources as well as organisation structure and control, are under concern in manufacturing planning, which in turn affect the capability of the manufacturing system to compete on basic performances such as cost, quality, delivery reliability and speed, flexibility and innovation (Safizadeh et al. 2000).

Stages and Gates

The method herein proposed consists of the typical phases of systems engineering. Hence, stages (and related gates) are organised through an analysis-phase, a design-phase and an implementation and realisation-phase. The analysis-phase concerns the study of the operational performances of different system design alternatives. The analysis-phase is needed for providing inputs to the subsequent design-phase, when the planning decisions are finalised by means of selection of the best manufacturing system (re)configuration and subsequent (re)organisation of its resources. The implementation and realisation-phase is intended in the broadest sense, since it covers the activities to be managed for (re)configuring/(re)building hardware structures, and service, manufacturing and control software, as well as for hiring and training personnel, and developing or changing the human organisation and control of the manufacturing facility.

Stage 1: Preparation and Introduction

In the stage 1 of Preparation and Introduction, a general plan of the development project and an appropriate project team is to be set up. After forming up the project team, the team members initially need to be familiarised with the idea of the PSS design, having a specific concern on the relevant implications for the operations of the manufacturing plant. Possible tools in order to scheme out the sustainability requirements may be taken from competence areas which are close or within the industrial engineering area. TQM (Total Quality Management) is a typical area where tools can be found, for example the *Quality Function Deployment* (QFD)—to relate stakeholder requirements to the requirements for the manufacturing system design. Another tool—originally proposed for strategic/management decisions, soon applied in many other contexts, also industrial engineering area—is the *Analytic Hierarchy Process* (AHP).

Gate 1: Preparation and Introduction

In gate 1, it has to be checked whether the project team really consists of all necessary experts needed in order to develop manufacturing planning solutions compliant to the stakeholders' requirements of the PSS under development.

Stage 2: Analysis of System Design Alternatives (economic and technical requirements)

Stages 2 and 3 are needed in order to analyse different system design alternatives, with the purpose to provide an assessment under the three known sustainability pillars. This stage 2 specifically focuses on the economic and technical requirements, taking into account the economic and technical factors related to the key operational requirements of the manufacturing system established at stage 1. Each system design alternative is then assessed after considering such requirements. On the whole, this analysis stage is carried on following a "traditional" manufacturing system design approach, with the purpose to support economic sustainability, and to compete on basic performances such as manufacturing cost, product quality, delivery reliability and speed.

Gate 2: Analysis of System Design Alternatives (economic and technical requirements)

To pass through this gate, the project manager has to decide in close cooperation with the project team whether the possible development project should be undertaken or not. For this reason, they have to decide, based on what they investigated and found out, whether there are enough alternatives to be further evaluated under other factors comprised in the environmental and social pillars, of interest for the stakeholders.

Stage 3: Analysis of System Design Alternatives (environmental and social requirements)

This stage 3 focuses on the environmental and/or social requirements, considering environmental and/or social factors related to the key operational requirements of the manufacturing system established at stage 1. Each system design alternative is then assessed after considering such requirements. At this stage 3, the environmental impact of different layout alternatives should be assessed. On the whole, a sustainable facility layout must be design and managed in order to optimise the energy flows of a plant and minimising wastefulness and inefficiency, for example by reusing the emission as an input for the system itself. More in details, an evaluation can be implemented only when the data about the consumption behaviour of each individual equipment included in the system is available. So, the first matter of concern of this approach should be to create a reliable database for the evaluation of energy consumption of each system and sub-system that compose the whole system: the database must contain the energy consumption of each component of the productive system, in order to be aware of energy consumption and losses regarding manufacturing, assembly and transportation. Last but not least, this stage 3 should also consider the work design and task analysis in order to understand how to match the demands of the system or process to human capabilities.

Gate 3: Analysis of System Design Alternatives (environmental and social requirements)

The project manager has to decide in close cooperation with the project team whether the possible development project should be undertaken or not. For this reason, they have to decide, based on what they investigated and found, whether there are enough alternatives from which the best manufacturing configuration may be selected for implementation (at next stage 4).

Stage 4: Selection of System Design Alternative

This stage 4 collects the assessment of all the system design alternatives that has passed the "go-decision" at previous stages 2 and 3. Moreover, it uses the key operational requirements established at stage 1 as control criteria to select the best manufacturing (re)configuration and (re)organisation of resources. In particular, at this stage 4 the main objective is to create a ranking of system design alternatives, as well as to present eventual sensitivity analysis on relevant factors, whenever this is the case in order to discuss on the robustness of manufacturing planning solutions under concern. For the ranking purpose, tools to enable the evaluation of the quality of manufacturing planning solutions should be used, considering also that multi-criteria decision-making (MCDM) is essentially required for properly weighting the priority of different sustainability factors: for example, *QFD* and *AHP* can be used in line with what is being used at stage 1. Other tools should be used for effective reporting and communication towards relevant project stakeholders.

Gate 4: Selection of System Design Alternative

The whole project team has to decide on the best system design alternative to be implemented.

Stage 5: System Design Implementation Plan

Stage 5, the implementation plan of the system design alternative chosen at stage 4 has to be set up, executed and controlled. At this implementation stage 5, it is relevant to focus on the so-called group development, as a follow-up of the result of work design and task analysis—already done at previous stage 3 to assign groups/individuals to operational activities/duties, as well as to analyse the human interaction with the technical system/s.

Gate 5

The project manager has to make sure that the implementation plan is complete, consistent and accomplishable. If it is not, he has to take care that appropriate improvements will be done.

Distribution and Logistical Planning

Distribution and logistical planning refers to the management of the flow of resources between the point of origin and the point of destination. The resources managed in logistics can include physical items, such as food, materials, equipment, liquids and staff, as well as abstract items, such as time, information, particles and energy. The logistics of physical items usually involves the integration of information flow, material handling, production, packaging, inventory, transportation, warehousing and often security.

Two main objectives in logistical strategy can be identified: firstly, companies strive to reduce cost, for instance fuel, taxes, salaries, etc. Secondly, not only variable costs, but also capital is to be reduced in order to ensure a stable market position. This capital may be reduced by diminishing investments and fixed costs. Finally, the improvement of the service quality is an important motive behind logistical planning.

Stages and Gates

In order to get a systematic understanding of the challenges, it is sensible to divide distribution and logistical planning into four thematic fields. First of all, each company is embedded in a legal system. Secondly, the economic and organisational framework of the company has to be considered. As a third issue, the production related conditions have to be considered. Finally, not only the company itself and the environment in which it acts have an influence on distributional questions. In the following, 4 stages and consecutive gates are suggested. Within each stage, the four aforementioned issues are kept in mind and explicitly addressed if necessary.

Stage 1: Production—When and Where?

As a first step, the aspect of *when* to produce a certain good is important. Dependent on the product's characteristics such as perishability, value, size, degree of immateriality (especially for service systems), or customer behaviour, for instance frequency of orders, it might make sense to produce a certain amount in advance to avoid supply shortfalls. In particular, companies with more than one factory have to consider *where* goods should be produced in order to minimise transport costs to the customer.

Gate 1

To pass this gate, it has to be checked whether the chosen production and delivery system is the most efficient one or not.

Stage 2: Potential Analysis/Audit

At stage 2 a potential analysis has to be done in order to compare the customer´s expectations to the company´s potentials. A potential analysis consists of five distinct analyses which capture, taken together, all relevant influential factors: requirement analysis, performance analysis, process analysis, structure analysis as well as *benchmarking*. The result of this analysis is a detailed idea of what the company has to provide in order to offer sustainable solutions and thus maintain long-term customer relationships. Beside economical sustainability, customer satisfaction has a high impact on social sustainability.

Gate 2

At the end of stage 2, several loops back to other division are advisable. The results of the requirement analysis can serve the planning of a single set of orders. Alternatively, they can be used to make predictions about customer behaviour as a whole.

Stage 3: Delivery Trajectory

Logistical planning tackles not only the question of how to deliver a product to its final destination; it also has to account for a combination of several orders. Thus, in order to increase sustainability, the most efficient solution regarding vehicle, optimal utilisation of capacities, fuel, but also time has to be chosen. Three different kinds of heuristic approaches can be used to guess systematic trajectories that might be preferred over bare arbitrary ones. Those are *heuristic approaches* (i.e. nearest neighbour), *the milk run method* and *the cross-docking method*.

Gate 3

The methods described should lead to an optimised delivery trajectory, taking several logistical options into account.

Step 4: Optimise Customer Satisfaction via Efficient Consumer Response (ECR) in Logistical Planning

In this step, the focus is changed towards customer satisfaction and, thus, a social and economic sustainability. The aim is to enable a company to react on consumers' demands as soon as possible by establishing long-term relationships and tool-based interactions between producer, wholesale trade, retail trade and consumer. ECR is a joint trade and industry body to make the market more responsive to consumer demand and promote the removal of unnecessary costs from the supply chain. One of those tools is *Quick Response* (QR) that tries to unify load units and informational systems of producer, wholesale trade and retail trade, especially designed for the grocery and fabric sector, QR-enabled companies to reduce their delivery times, an increase on deliveries on time, less waste and a reduction of costs.

Service and Spare Parts Operational Planning—Maintenance

Nearly every organisation today is looking for some ways to improve maintenance. Proper maintenance does not only help to keep the life cycle cost down; it also contributes positively to the overall performance of the company. However, maintenance also contributes significantly to the total cost, and this often forms the basis of performance improvement demands to the maintenance department (Waeyenbergh and Pintelon 2002). The search for maintenance improvements is focused on finding a programme, approach or methodology that will improve the productivity of maintenance labour whilst at the same time improving production equipment reliability, availability, and productivity (Kister and Hawkins 2006).

Stage 1: Assessment of the Current Situation; Definition of the Maintenance Policy, Strategy, Objectives and KPIs

At the beginning of stage 1, the whole maintenance planning process gets started. An assessment of the current situation has to be done. It must consider all aspects related to the maintenance of equipment where information is available. After this is done, the production or authorisation of the overall maintenance policy by the organisations´ top management has to be realised. The maintenance policy provides the framework around which the maintenance strategy, objectives and plans are developed and implemented. The result will be the development of the draft maintenance policy. After this done, the organisation will establish or review a long-term maintenance strategy. The maintenance strategy has to demonstrate how the maintenance policy is to be implemented and how it will support the organisational strategic plan. After this done, the organisation will establish or review a long-term maintenance strategy. The maintenance strategy has to demonstrate how the maintenance policy is to be implemented and how it will support the organisational strategic plan. If the objectives and strategy as well as the performance measures are inconsistent with the declared overall business strategy, the *balanced scorecard* (BSC) has to be introduced (Kaplan and Norton 1992).

Gate 1

After stage 1 is done, it has to be checked whether the assessment of the current situation in the maintenance management of the organisation considers all aspects related to the maintenance. After this done, it has to be checked whether maintenance policy, strategy, objectives and KPIs are clearly defined. Furthermore, it should be checked whether the maintenance policy is consistent with the organisational strategic plan.

Stage 2: Assets Priority Considering the Sustainability Factors

Once the objectives have been defined and a maintenance strategy has been designed, it is of vital importance for the management of the maintenance department to establish the ranking of the physical assets of the organisation based on their criticality, e.g. greater or lesser impact in the global production system and/or safety of the system (business objectives). There are many qualitative and quantitative techniques that offer a systematic basis for classifying an asset as critical (C), semi-critical (SC), and non-critical (NC) based on probabilistic risk assessment and obtaining the “probability risk number” (PRN) (Moubray 1997).

Gate 2

To pass this gate, the management of the maintenance department has to control if every asset could be classified in a critical (C), semi-critical (SC) and non-critical (NC) class to get a clear overview about it.

Stage 3: Design of Maintenance Plans and Resource Allocation

At the beginning of stage 3, data from computers have to be analysed. Thereby, the different functions of equipment have to be identified. Next, failure modes have to be identified. It presents the base for the decision. Finally, the root cause of failures has to be analysed if required. With all these data, it assesses the consequences of each failure in each of the areas (operational, safety, environment and cost). After this done based on the collected information, a decision has to be taken. The decision has to set out prevention duties (technically feasible and economically profitable) for the consequences of failure modes. One of the methods used in the industry for designing strategies and maintenance plans is referred to as RCM (reliability-centred maintenance). The *RCM methodology* proposes the identification of failure modes that precede potential failures of equipment, and the execution of a systematic and uniform process.

Gate 3

Firstly, it is to check whether the maintenance plans consider all needed resources and required inventory which could be done without including the upper maintenance management. Furthermore, the middle management has to check whether all the mentioned restrictions are considered and met in the work of stage 3.

Stage 4: Implementation, Execution and Control

At the beginning of the stage 4, the design of the information system has to be checked if it is oriented to collect and to process exact information. After this done, the tasks and the persons in charge have to be subdivided in accordance to the maintenance plans. The execution of maintenance activities (once designed, planned and scheduled as described in previous sections) has to be monitored and evaluated to pursue the business objectives (business model development; strategy development) and business values of the selected maintenance KPIs. This survey and evaluation have to be done by a structured control report.

Gate 4

Firstly, it has to be checked if the information system was created and implemented in the right way in order to store and handle the historical data. The next aspect to control is the structure and the content of the report for the maintenance execution.

Stage 5: Life Cycle Analysis and Replacement Optimisation

Therefore, in the stage 5 have to be performed the evaluation and analysis of the life cycle costs of the maintenance assets. The realisation is a responsibility of the middle management of the maintenance department.

Gate 5

At the beginning of this stage, the applicable maintenance functions in each of its phases (design, manufacturing and production, etc.) have to be identified. After this done, the cost of these functions has to be calculated, applying the appropriate cost for the duration of the life cycle. Finally, the total life cycle costs have to be analysed. Through an analysis of the life cycle cost, it is possible to determine the cost of an asset over its useful life. *The life cycle cost analysis* (LCCA) or the sustainability *impact calculation tool* (SIC) has to be used. Further on, other tools for asset life cycle simulation may be adopted, having the capabilities to represent stochastic behaviour in time.

End-of-Life and Recycling Planning

The end of a product's life cycle causes various difficulties concerning its disposal. These difficulties mainly affect environmental issues, but may also have impacts on the company's profitability or society. In order to attain an increasingly sustainable positioning of the company, it is necessary to ensure that a gross of the materials is reusable or can be environmentally friendly disposed.

The concept of recycling is used ambiguously and refers either to all kinds of waste disposal reusing components or the whole material of the product, or merely to a disposal which ensures a consistent quality of the reclaimed raw material.

Stage 1: Building a Prototype

At the beginning of each consideration about a product's end of life, a prototype is necessary. This prototype, either already physically available or a mere drawing, should be designed on the company's former experiences. It builds the basis for the following attempts to design a product that can easily and environmentally friendly be recycled.

Gate 1

To pass through this gate, specialists for end-of-life cycle planning have to talk to specialists from other divisions and check whether the prototype is realisable.

Stage 2: Reduction

Tear down is a procedure to improve existing physical goods in order to increase their sustainability. The aim is to find potentials for leaner designs which lead to cost reductions and an increased recyclability.

Gate 2

At the end of the second stage, each component must have been considered in various arrangements, using different materials, shapes or spatial order. McDonough and Braungart defined five criteria which support the reflection process (McDonough and Braungart 2002).

Step 3: Reuse

The persons responsible for the planning phase need to find alternative ways of use for the raw materials at the end of the product's life cycle. The most evolved approach to intelligent or sustainable product design is the cradle-to-cradle (c2c) conception. Its leading idea is the vision of a world without waste. The *c2c approach* was developed in 2002 by Braungart and McDonough (McDonough and

Braungart 2002). After the theoretical considerations concerning the new product's recycling, the real process of recycling has to be conceptualised.

Gate 3

The ratio of per se environmental friendly materials and the waste they bring about during their manufacturing has to be considered and be rechecked after step 3.

5 Case Study CLAAS Selbstfahrende Erntemaschinen GmbH

CLAAS Selbstfahrende Erntemaschinen GmbH is part of CLAAS KGaA mbH, an international operating manufacturer of agricultural machinery. The company employs over 9,000 people and has yearly revenue of 3.4 billion Euros (in 2012). CLAAS is facing the challenge to change their classical business model from a product selling company to one that is selling sustainable solutions for their customers. The introduced development framework should serve as a guideline to optimise the way of developing sustainable solutions and illustrate weaknesses in the present one.

Procedure

In a first step, employees of different divisions of CLAAS were introduced to the development framework and familiarised with the suggested dimensions. The different dimensions, activities, gates, responsibilities and interfaces were explained. The next step was a discussion about the dimensions and the four suggested development phases.

After the structure of the framework had been accepted and considered as complete, the next task was to classify the different roles of the participants into the given dimensions. Afterwards, the participants were asked to draw down their actual procedure for sustainable solution development into the development framework. After identifying many possible starting points for new solutions, the process for collection, assessment, prioritisation up to the decision and realisation was signed into the framework. During this procedure, many weaknesses of the actual processes were shown. For example, not explicitly defined, but necessary interfaces were identified. After drawing the actual development process and identifying weaknesses whilst doing so, a last step should be the design of target processes. Therefore, the introduced scientific development framework gives useful incentives, tools, ideas and recommended interfaces and gates to define the target processes. The consideration of different sustainability goals must also be considered whilst creating the new target process. Tools to measure and monitor sustainability goals should be integrated.

Lessons Learned

The following eight examples give a first impression of what can be analysed using the framework. They cover a broad range from issues that address interfaces between divisions as well as organisational and communicational weaknesses. The challenges CLAAS has to respond to should be seen in the context of the change from a physical product to product-service systems; a change whose necessity is confirmed by international scientific authorities.

- Communication channels between existing strategies and different divisions need to be improved in order to reach more target-orientated ideas.
- Consolidation of multidimensional idea sources should be structured in a suitable one-pager.
- One-pager, as a first outline of the idea, should also show the sustainability impacts (economical, environmental, social).
- Arrangements of higher capacities for a structured idea description and idea preparation.
- The process of idea generation is mostly based on machinery improvements. A more integrated view is missing.
- Arrange more flexible capacities to guarantee a successful realisation of projects within a project organisation.
- Missing interfaces within the organisation for the realisation of new innovative solutions.
- Mostly the innovation is machinery based. So interfaces to the central initiation are important. Loops between the PSS development and the strategy, respectively, the business development is most important.
- For the development of sustainable solutions, new issues, e.g., data privacy, ecological impacts and measurements must be considered. Therefore, interfaces from technical development to other divisions of central initiation are necessary. Due to the occurrence of new issues during the development process new responsibilities occur, too. These responsibilities are often not defined.
- Identified or existing interfaces between different divisions are sometimes using different IT standards. These circumstances lead to mistakes and hinder an efficient sustainable solution development.

6 Conclusions

The scientific achievement of the previous chapters is a framework that is supposed to be a tool and a guideline for companies or value networks to evaluate and optimise their current business processes. In this framework, which serves as a rough generalisation over prototypic companies, 3 groups—central initiation, conceptual dimension and operational dimension—consisting of eleven dimensions has been defined. The processes are divided into four chronological steps according to the life cycle approach of the methodology: idea, conceptualisation, implementation and market. For each unit, several steps and gates are defined which contain a manifold of tools and methods in order to realise sustainable solutions and to optimise business processes. Whilst the steps provide a suggestion for a possible procedure, the gates serve as moments of reflecting and checking whether the aims of a step have been fulfilled and the processes are as sustainable as possible. The result is thus a framework that covers all business activities and explicitly suggests a detailed procedure for each division for each step in the development of sustainable solutions based on scientific approaches from considerable authorities in their field and confirmed by real companies via workshops. The aim is to enable companies to optimise their business processes towards sustainability, starting at any point in their process chain.

For an international operating company with a complex structure of functionalities and divisions, the development framework seems to be a meaningful and helpful method for realising sustainable solutions. When it comes to interfaces, the most eminent challenge is an improvement of communication processes. If companies or value groups are able to make improvements here by involving all relevant actors in the decision-making process, various immense problems, delays and complaints might be avoided.

Summarising we can conclude that the development framework is on the one hand a useful and helpful guideline to get an overview of topics to be dealt with when developing sustainable solutions. On the other hand, the framework can be used as a tool for companies to define their development processes.

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Methods and Tools for Sustainable Development of Products and Services

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1 Introduction

This chapter aims to provide companies with tools and methods for the analysis and optimization of their processes in order to increase sustainability. Based on the development methodology for sustainable solutions presented before, which combine and integrate various management and operational methods and supportive tools, this chapter offers a useful tool and method box for the development of solutions that ensure maximum value of products, services, and processes throughout the complete life cycle. This box enriches all the phases of the methodology for a structured and efficient development process with practical tools assisting as well as implementing a structured development.

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2 Identification of Requirements for Tools and Methods Characterizing Their Applicability for Sustainable Solutions

Before developing new tools and evaluating existing approaches, it is important to identify requirements that tools for a structured and efficient development process for sustainable solutions should fulfill. The most relevant general requirements for tools and methods for a structured and efficient development process are the following:

Time required
The time needed to implement a tool is an important aspect to be considered. In fact, depending on the type of decisions and the willingness to spend time to find an output, some tools could not be a viable option in case availability of decisions makers is limited. The requirement is here that the tools can be used in workshops.

Skills and knowledge required
Some tools could require either specialized knowledge or particular skills to be applied, that is not always owned by a company. If the tool is too complex from this point of view, either external expertise is needed or the tool cannot be used. In our particular case, a tool that does not require a high level of skills and knowledge is preferable.

Data required
Any tool needs a set of input information/data to be used. It has to be noted that the easiness of gathering data could depend also on the specific company/sector where the tool has to be applied.

Availability of the tool
This criterion is meant to specify whether the tool is already available and can be used as it is ("on the shelf") or has to be developed according to the needs of the business modeling process (to be adapted).

Possible use of the tool
Scope of tools can be slightly different when applied to the engineering process. It was observed in some cases (e.g., validation of business model tools) that the tool has to be intended as a set of guidelines, a supporting checklist rather than a tool.

Configuration of the tool
In order to provide accessibility for everyone, the tool should be applicable to different branches and companies. Therefore, a universal framework should be used which simultaneously ensures a configuration possibility, depending on the need of the specific-use case (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006).

Application-orientated development
In order to guarantee a wide range of practical usage of the tool, requirements from different user groups should be considered. The tool should be practice-orientated

while the advantages of the tool usage are obvious to the user. This is a significant factor for the success of the tool. The application of each step should be easy to understand plus the execution of the single steps should contain only small complexity. An applicable and efficient design of the method and its devices is necessary; this turns out to be an extra challenge as the users normally derive from different business sectors and departments and therefore look differently on products and processes (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006).

Customer friendliness
The tools and methods should be easily usable for customers; hence, the workings steps are to define clearly with low or moderate complexity. The steps should be clearly arranged. Tools are often not accepted because they fail to address the commercial activities of a company, so the users' interests should be ranked first. The look of the tool also plays a decisive role; the design should be clear and appealing (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006).

Value Network
Creation of a wide and transparent value network should be generated and exploited including partners from different business sections in order to provide a wide and holistic view on the problem (NaNuMA—"Nachhaltige Nutzungskonzepte für den Maschinen- und Anlagenbau" 2006)

3 Toolbox for the Development Methodology for Sustainable Solutions

The Development Methodology for Sustainable Solutions presented in Sect. 4 in Chap. "Development Methodology for Sustainable Solutions" suggests working with certain tools at different stages and gates in the development process of different dimensions. Below a general overview of the recommended tools is presented categorized by development phases and a compact presentation of the concrete tools. In the overview below, the different tools that are used in the Development Methodology for Sustainable Solutions are separated into the four dimensions—central initiation, conceptual dimensions, operational dimensions, and general use in all dimensions.

Tools for the central initiation

- Value mapping tool,
- Sustainable business model (SBM) archetypes,
- System SWOT analysis, PESTLE/STEEPLED, and Sustainability Continuum,
- Osterwalder and Pigneur Business Model Canvas,

- Global Reporting Initiative (GRI) and Sustainability Accounting Standards Board (SASB),
- Road-mapping,
- Sustainability matrix,
- Strategic portfolio management.

Tools for the conceptual dimensions

- Brainstorming,
- LCC estimation tool,
- Sustainability impact calculation tool (SIC-Tool),
- Scenario management tool,
- FMEA tool,
- Service Blueprinting.

Tools for the operational dimensions

- Balanced scorecard and
- Supplier evaluation matrix.

Tools for the general use in all dimensions

- Maturity assessment model and
- Systems dynamics.

3.1 Tools for the Central Initiation

Value Mapping Tool

This tool assists in stimulating innovation and developing new sustainable value proposition/s, while helping in the analysis and design of sustainable business models through mapping various forms of value and analyzing exchanges from a multi-stakeholder perspective across the industrial network. The value mapping tool is proposed to help companies understand and create new value propositions to support business model design for sustainability.

The objective of business model design for sustainability is to transform destroyed and missed value opportunities into positive new value creation.

The tool is envisaged to have applicability to all business modeling activities, from exploring opportunities for new start-ups, to assisting in redesigning business models for established large corporations. Use of the tool and the design of any workshops to use the tool should be adapted to the size and complexity of the business. For more complex businesses, it may be desirable to focus on specific business units or product lines to ensure the process is manageable. To maximize the potential of the tool, representatives or suitable proxies for each major stakeholder group should participate in the process to solicit broad perspectives on value.

Sustainable business model (SBM) archetypes

This tool supports in the transformation of the new sustainable value proposition by providing a selection of groupings and mechanisms that help in delivering business model innovation for sustainability.

The SBM archetypes describe groupings of mechanisms and solutions that might contribute to building up the business model for sustainability. The notes below summarize the sustainable business model element archetypes along with supporting examples of such innovations in practice. The main aims of the archetypes are to:

- Provide a means of categorizing and explaining business model innovations for sustainability through exemplars.
- Define generic mechanisms for actively assisting the innovation process for embedding sustainability in business models.

The archetypes adapted from (Short et al. 2012) are:

– Maximize material and energy efficiency (i.e., lean low carbon; increase functionality),
– Non-finite benign resources/processes (i.e., renewable energy sources, zero emissions solutions),
– Create value from waste (i.e., Cradle2Cradle; reuse; upcycling),
– Deliver operability rather than ownership (i.e., pay per use),
– Encourage sufficiency (i.e., consumer education; slow fashion),
– Adopt a stewardship role (i.e., fair trade; biodiversity protection),
– Repurpose business for society/environment (i.e., localization),
– Develop scale up solutions (i.e., licensing, franchising).

SBM archetypes supports in the transformation of the new sustainable value proposition by providing a selection of groupings and mechanisms that deliver sustainability

System SWOT analysis, PESTLE/STEEPLED, and Sustainability Continuum

These tools are already available (on the shelf) and have been used in industry. They are included as they support in defining the business purpose, industry-related requirements, norms, and opportunities including the firm position on sustainability (current and future) and its drivers.

The *SWOT analysis* is part of the output of SUSPRONET project (Tukker und Tischner 2006). The generic SWOT analysis tool was adapted to include sustainability dimensions and technology and legislation aspects. The objective of the tool is to assist firms in identifying the current and future **s**trengths, weaknesses, opportunities, and threats of the firm (business model) for sustainability.

PESTLE and STEEPLED constitute extensions of the PEST analysis (Political, Economic, Social, and Technological analysis). *PESTLE* includes legal and environmental factors and apart from the previous, STEEPLED adds also education and demographic factors. These are considered as macro-environmental factors that an organization has to take into consideration when studying its business environment.

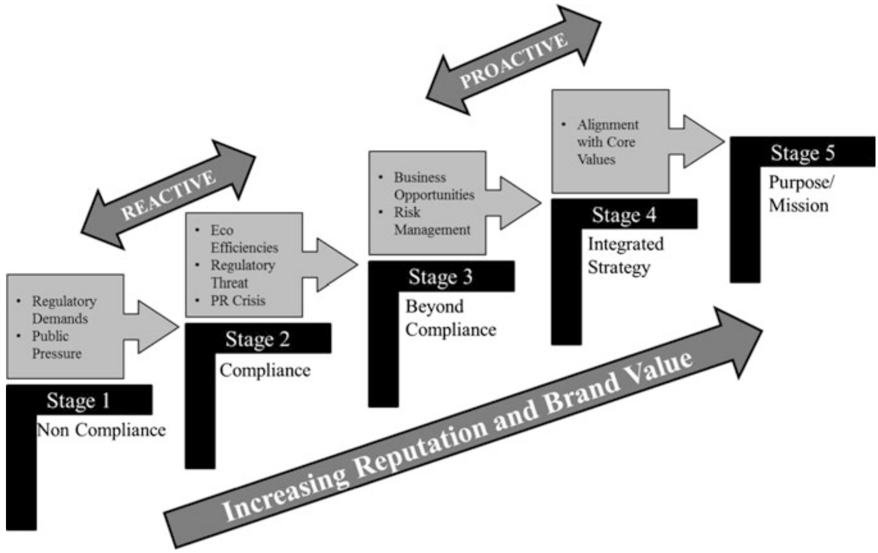

Fig. 1 The corporate sustainability continuum (adapted from Willard 2005)

It is considered as a useful strategic tool and could potentially provide additional support to the scenario management tool in understanding the current and future factors influencing the business environment.

Willard proposed the "*corporate sustainability continuum*" which represents the progress of firms on the path toward sustainability (Fig. 1) (Willard 2005). Hence, it is included in step 1 to help firms in conducting a similar study of current and future path for sustainability, which will potentially be an input to the analysis, carried out in steps 2 and 3.

Osterwalder and Pigneur Business Model Canvas
This tool supports in the coordination and configuration of the key activities, resources, partners and channels, and the value exchanges and value capture for the stakeholders across the network.

Osterwalder and Pigneur's book "Business Model Generation" offers a business model canvas and guide for working through business model conceptualization (Osterwalder und Pigneur 2010). The business model canvas seeks to develop a more generic framework with broad applicability across all industry sectors, utilizing a standardized vocabulary and semantics. Their canvas attempts to capture all the dominant components from the existing literature, and is made up of nine building blocks. Their more recent iteration of the framework renames value configuration and capabilities to give a business ontology of value proposition, customer segments, channels, customer relationships, key resources, key activities, key partnerships, cost structure, and revenue streams (Osterwalder und Pigneur 2010). The canvas places emphasis on defining concrete processes and operational activities. Hence, it has been selected as a tool to assist in developing the value creation, delivery, and capture mechanisms.

Global Reporting Initiative (GRI) and Sustainability Accounting Standards Board (SASB)

The GRI framework was developed by the United Nations Environment Program (UNEP) along with the Coalition for Environmentally Responsible Economics (CERES) for solidarity in sustainability reporting (Labuschagne et al. 2005). The guidelines cover all three pillars of sustainability—environmental, economic, and social. It is intended to assist firms in sustainability reporting. Some examples of indicators for the three pillars of sustainability are as follows.

- Economic: wages and benefits, job creation, expenditures on outsourcing, research and development, investments in training, diversity, and other forms of human capital; traditional financial information;
- Environment: impact of activities, products, and service on air, water, land, biodiversity, and human health and welfare;
- Social: workplace health and safety, employee retention, human rights and diversity, wages, and working conditions at all company locations and out-sourced operations.

The SASB approach includes "a concise and relevant sustainability accounting standards that enable companies to describe material sustainability issues affecting performance and long-term value creation" (Labuschagne et al. 2005). It provides condensed versions of sustainability indices that will potentially prove more manageable and relevant to industry and investors. The focus is on materiality—what really matters in the business. SASB have proposed sector specific sets of indices to reflect the different materiality issues of different sectors. This emphasizes on the link between business model, corporate strategy, and sustainability issues.

Road-mapping

There are several methods used in technology management, of which technology road-mapping (mapping technologies against business and market needs) is one. Road-mapping is a strategic planning tool for forecasting both the critical development needs and the steps required to reach major advances in an area studied (Glenn and Gordon 2009), and it has been defined as an approach for aligning technology and commercial perspective, balancing market pull, and technology push (Phaal et al. 2004). Through technology road-mapping companies gather information from different sources to develop near-, mid- and long-term plans for new product and process developments and R&D investments. In addition to gathering information outside the company, road-mapping tool integrates all levels and functions within a company together into a framework and a common plan. The main idea of technology road-mapping is to identify the technologies that underlie current and planned products and also to highlight the known technology developments, and the elements that will be needed to successfully develop the new product. Thus, it formulates the link between technological resources and the long-term market opportunities and integrates technology developments with business planning, assessment of the impact of new technologies and market developments. (Shebabuddeen et al. 1999; Petrick and Echols 2004; Phaal et al. 2004). Typically technology road map is a graphical, time-based framework that presents strategic plans, critical elements and paths of the future developments on three layers, which are “technology,” “products,” and “markets” (Aholy et al. 2010) (Ahlqvist et al. 2010). The strength of the road-mapping approach is in the identification of obstacles, as well as solutions for dealing with these obstacles, and in the generation of shared targets and a common vision of where the company is going (McDowall and Eames 2006; Phaal et al. 2004). Therefore, in addition to integrating technology planning to business planning, technology road maps have been used in corporate strategy work and vision-building (De Laat and McKibbin, de and McKibbin 2003). The authors summarize the benefits of road-mapping into two: road-mapping enables the identification of drivers, bottlenecks and possible applications in a timeframe, and on the other hand the process can function as consensus and agenda-setting procedure.

Sustainability matrix

Sourcing planning can be divided into two main stages: strategic level in which the main task is to set targets to sourcing, and operative level in which possible suppliers are searched and evaluated. Strategic network and stakeholder analyses are an important part of setting strategic objectives for sourcing for sustainability. A sustainability matrix is a tool with which strategic targets and sustainability objectives can be set and coordinated over the boundaries of a company, and with which the diverse interests of involved actors can be evaluated and aligned (SustainValue D3.3 2012).

Sustainability matrix has been modified from corporate social responsibility (CSR) matrix that is an important strategic tool and a conceptual framework that assists managerial decisions by integrating CSR components with organizational stakeholders (Carroll 1991). CSR matrix gives an overview of the degree of importance of key CSR issue and key stakeholder and illustrates the relations between them. Therefore, the matrix includes three dimensions, key issues, key stakeholders, and the importance of each issue to each stakeholder, and thus, the matrix portrays the profile of issues for each stakeholder. With information on the importance that different issues have in regard to different stakeholders, CSR matrix helps in prioritizing CSR strategic actions and makes it possible to analyze the common and conflicting issues for stakeholders (Jansson 2008; Papaloannou and Pettersson 2012). It is a valuable tool for analyzing the strategic situation also in international stakeholder management (Jansson 2008).

In the CSR matrix, the different shading in the cells illustrates the importance of each issue for each stakeholder: the darker the shade of the cell, the more important the issue is for the stakeholder in question. Thus, CSR matrix supports companies in identifying the key issues from the view point of their key stakeholders (see Fig. 14).

Since the institutional settings differ between different situations and companies, so do the key issues and key stakeholders that are depicted in the matrix. Therefore, CSR as well as sustainability matrix needs to be formulated case-specifically.

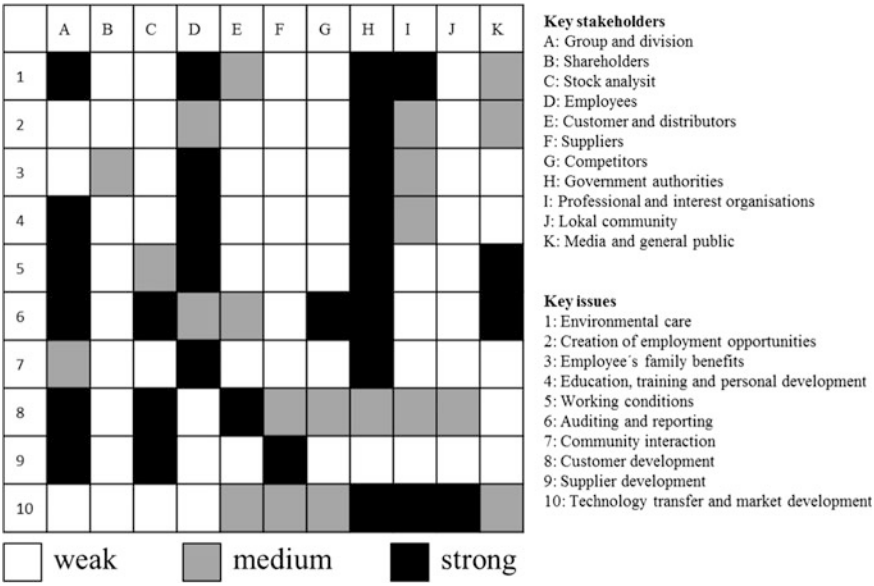

Fig. 2 An example of CSR matrix (adapted from Timlon 2011)

Strategic Portfolio Management

A company has to evaluate project opportunities and make decision how to allocate their resources appropriately to implement their business strategy. Strategic portfolio management refers to the management process that is used to control these portfolio decisions in a R&D company or network.

Cooper et al. (1999) defines portfolio management as a dynamic decision process that consists of revising company’s list of current product and R&D projects. This process involves evaluating new and existing projects, selecting or killing projects and prioritizing projects in the company’s project portfolio. The portfolio management process is linked to many of the company’s decision-making processes. Cooper et al. (2001) define four goals for portfolio management: maximizing the value of a portfolio, seeking the right balance of projects, ensuring that the portfolio is strategically aligned, and making sure you do not have too many projects for limited resources. All in all, portfolio management is about making strategic decisions about markets, businesses, products and technologies, and about resource allocation within a company.

Strategic portfolio management can involve multiple different portfolio management techniques. These techniques can be classified in different categories, such as financial methods, optimization methods, multi-criteria methods, mapping methods, strategic approach, and behavioral approach (Cooper et al. 1999; Cantamessa 2005).

3.2 Tools for the Conceptual Dimensions

Brainstorming

Brainstorming is the best-known and significant representative method of intuitive creativity techniques, which are applied in order to support idea finding in the problem solving process in the business environment (see Eversheim 2008, 53).

Two types of brainstorming are known: traditional verbal brainstorming and electronic brainstorming (EBS) (Dennis et al. 2013, p. 139). The *classic brainstorming* process involves generating ideas by focusing on generating a large quantity of ideas while deferring evaluation until a later session. The assumption is that by generating a large quantity of ideas, there is an increased probability of producing good solutions (Paulus et al. 2013). The *electronic brainstorming* is a new computer-aided technique, which involves group members sitting at computer terminals and typing in their ideas, but also having full access to the others' ideas as they are produced (Furnham 2000, p. 27). EBS involves use of a technology such as e-mail, browser based systems, text-based chat, group support systems, and vendor-specific tools to facilitate the brainstorming process.

Furnham specifies a number of rules which have been developed to ensure that a brainstorming session is properly conducted (Furnham 2000, 22): Group size should be about five to seven people. No criticism is allowed. Freewheeling is encouraged. Quantity and variety are very important. Combinations and improvements are encouraged. Notes must be taken during the sessions. The alternatives generated during the first part of the session should later be edited for duplication and categorizations

The session should not be over-structured by following any of the preceding seven rules too rigidly.

Life Cycle Costing Estimation tool (LCC)

Life cycle costing is the process of economic analysis to assess the total cost of acquisition, ownership, and disposal of a product. The analysis offers important information for the decision making in the product design, development, use, and disposal phases. The LCC tool calculates and estimates the costs and effects of products or solutions during their life cycle. Up to five solutions can be compared simultaneously according to their annual and life time costs. The tool has three main cost categories takes into consideration in estimating the lifetime costs: acquisition costs, use costs, and disposal costs. The acquisition costs include all the costs related to acquisition and installation of the solution. The use costs are annual costs, such as maintenance costs and electricity costs. All costs that relate to recycling of components and materials as well as waste management costs are considered disposal costs.

Because the LCC tool estimates future costs the estimations include some amount of uncertainty. The LCC tool assesses this uncertainty by concluding a sensitivity analyses with Monte Carlo simulation. The simulation performs multiple calculations for situations where the future costs differ from those that were originally estimated.

Sustainability Impact Calculation Tool (SIC-Tool)

Target of the Sustainable Impact Calculation tool is to measure and assess sustainability impacts of products, services, or product service systems on society, environment, and economy. During the development process of new solutions (in form of services, products or a combination of both), a clear transparency of the long-term consequences of these solutions is needed. Even promising ideas which seems to be an improvement regarding sustainability could lead to an unexpected negative impact regarding sustainability. The Sustainability Impact Calculation tool should help to create transparency and gain an overall view of the possible sustainability impacts. Therefore, the three pillars of sustainability were assessed with the help of different KPIs. The underlying idea is that the same input data may be used to calculate impacts in different dimensions: For example, data about energy consumption are affecting costs (economy), but also resource depletion and emissions (environment).

Scenario Management tool

Scenario analysis is a procedure based on the development of different theoretical scenarios. Furthermore, the scenarios will be compared and evaluated toward their results, respectively, consequences. Objective of the scenario analysis is to anticipate future developments of society and find and evaluate possibilities and strategies to meet these developments (D3.3 2012—FIR).

The tool was used to create more transparency of possible future developments regarding possible changes in the environment of the agricultural business. During the usage of scenario analysis tool, all three pillars of sustainability were considered. Economic interests and new market potentials were discussed as well as investigations for some possible technical developments (e.g., Internet connectivity in areas with fewer infrastructures) were organized. The identification and investigation of new environmental benefits through process optimizations were recognized as well. Even social aspects (e.g., guidance and comfort for drivers of harvesters and tractors) were addressed.

FMEA—Tool

FMEA stands for Failure Mode and Effects Analysis. The target of this tool is to improve the reliability of services, products, or processes. Based on the identification of weaknesses, the quality and the security of products, services, and processes should be assessed and improved in a second step. The tool should be used in an early stage of development to detect potential failures before they occur. So the FMEA analysis supports a preventive avoidance of failures. The advantage is that cost can be saved and security issues can be improved. Hence, the economic and social pillar of sustainability can be improved primarily. The FMEA analysis consists of five essential steps. First of all the system or the process must be identified. For the adequate description of the process, the tool Service Blueprinting could be useful. The second step is to define an adequate level of abstraction. After the identification of the main systems (parts, modules or activities), each system must be analyzed regarding weaknesses and potential failures. Each potential failure must be assessed regarding three criteria. The first criterion is the probability of occurrence. This criterion classifies how often the failure will probably occur. To estimate the probability, a scale from 1 to 10 (improbable to high) quantifies the risk. The same scale is also used for the other criteria which are impact and likelihood of detection. After this risk assessment, the multiplication of the assessments reveals the priority number of the analysis. The last step is the definition of measures which helps to reduce the high priority number. For the three different alternatives are possible. On the one hand, measures have to decrease the probability of occurrence or the likelihood of detection. On the other hand, the impact of possible failures must be reduced with the help of the measures.

Service Blueprinting
The tool service blueprinting is basically a map or a flowchart of all service activities which are necessary to satisfy the customer needs. The tool provides some advantages. First of all, it provides a complete sketch of the service processes which leads to complete transparency of the process. This helps to communicate with other colleague's or division about the service process avoiding misunderstandings. Further, it is possible to identify relevant interfaces and necessary infrastructures. While developing the service processes with the help of the service blueprinting tool, the feasibility and the identification of potential failures occur automatically. The last mentioned advantage enhances another described method which is called FMEA (the FMEA method is also described in this document of D3.4). Different processes can be analyzed with the help of the FMEA surfaces after the first draft of the service process. The tool should be used in an early stage of development to detect potential failures before they occur and to get transparency of the process. With the help of a special structure, the processes can be drawn.

3.3 Tools for the Operational Dimensions

Balanced Scorecard
With the BSC, the management of the company can monitor and measure the activities of the company and their consistency with company's strategy. In other words, the BSC is a tool for transforming strategy into actions. The idea of the BSC is to introduce also other than financial aspects in the organization's strategy process (Kaplan und Norton 1992).

The BSC measures organizational performance from four perspectives: financial, customer, internal business process, and learning and growth. The financial perspective indicates if the strategy leads to improvement in economic success. The customer perspective defines the customer and market segments in which the business competes and the measures for the customer value propositions. The internal process perspective identifies the internal business processes that enable the organization to meet the expectations of customers and shareholders. The learning and growth perspective identifies the infrastructure necessary to achieve long-term

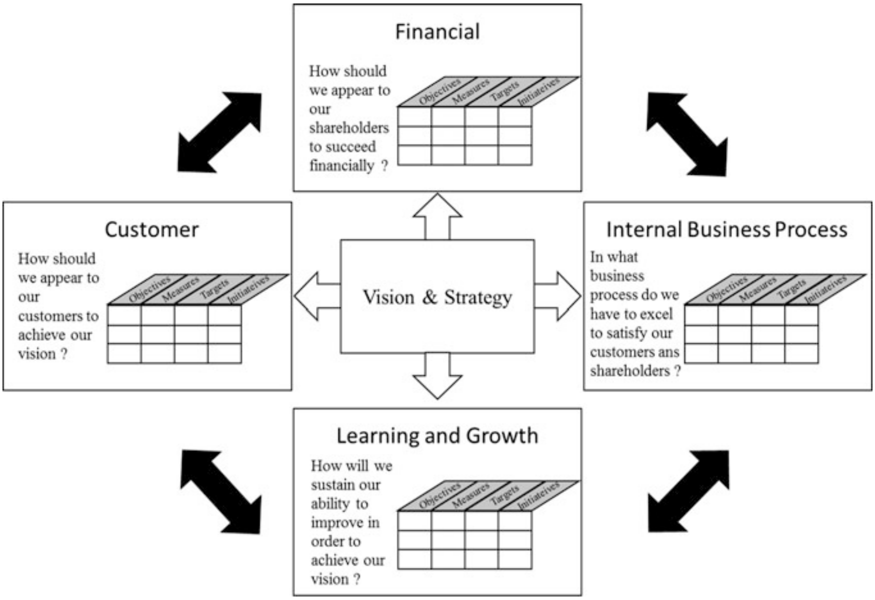

Fig. 3 Balanced Scorecard (adapted from Kaplan und Norton 1992)

growth and improvement. Each of these aspects includes strategic objectives, measures, targets, and objectives as shown in the Fig. 3 (Kaplan und Norton 1992).

The original Balanced Scorecard methodology by Kaplan and Norton has been developed further to match various needs in the modern business environment. One of the developed applications is the Sustainability Balanced Scorecard (SBSC), which adds social and environmental aspects of sustainability to the original framework. The incorporation of these aspects can be done by various different ways (Figge et al. 2002; Nikolaou and Tsalis 2013). According to Figge et al. (2002), there are three different possibilities to integrate the sustainability aspects in the BSC: integrating them in the existing standard perspectives, adding additional perspective, or formulating a special environmental and social scorecard. Nikolaou and Tsalis (2013) introduce a model where the Global Reporting Initiative's GRI guidelines are integrated with the BSC. The indicators from the GRI guidelines are used as indicators for the four BSC perspectives.

Supplier evaluation matrix

In sustainable supply chains, environmental and social criteria need to be fulfilled by members in order to remain within the chain, as it is expected that competitiveness would be maintained through meeting customer needs and economic criteria. As a response, companies have started to introduce different kinds of supplier evaluation schemes (e.g., standards, sets of criteria, supplier self-evaluation) integrating the three dimensions of sustainability criteria. With the evaluation, companies aim not only to avoid risk that can be related to the three dimensions of sustainability, but also to ensure the product quality and the performance of the operational process (Seuring and Müller 2008). Effectual selection and evaluation of suppliers and promoting their involvement in critical supplier chain activities will result in improved firm performance via enhanced customer satisfaction (Tracey and Tan 2001). Strategic network and stakeholder analyses are an important part of setting strategic objectives to sourcing for sustainability. Supplier evaluation matrix is a tool that can be used especially when a company is defining criteria for, categorizing and finally selecting its suppliers (contract partners). In order to make the decision between the possible suppliers or partners, it is important to compare their characteristics, such as their resources, competences, and commitment related to cooperation and sustainability. The different risk management and purchasing portfolio criteria can also be utilized for this purpose. Supplier evaluation matrix gathers together various contract partner attributes which are ranked on a scale from 1 to 5 and evaluated in case of each supplier candidates.

3.4 Tools for the General Use in All Dimensions

Maturity assessment model

Maturity models normally include a sequence of levels (or stages) that form an anticipated, desired, or logical path from an initial state to maturity (Röglinger et al. 2012). One of the widely discussed maturity models is the Capability Maturity Model Integration (CMMI) which derives from the Capability Maturity Model (CMM) introduced by Paulk et al. (1993). CMM bases on the idea that improvement is done by little steps rather than by radical changes, by focusing on some process areas and by adopting some key practices therein (Macchi et al. 2011). The CMMI is a de facto standard, originally proposed for the maturity assessment in the software engineering domain, soon applied to many other application domains in business development (project management, supply chain management, etc.). Maturity assessment for network conditions and structural elements is a maturity model developed in the Work Package 4 of SustainValue project. The model is a part of the Integrated Assessment Platform for Sustainability Performance in Value Networks framework. The maturity assessment framework is developed on the basis of the CMMI methodology and is used together with the Triple Bottom Line (TBL) assessment to improve sustainability performance in value networks. The maturity assessment model defines process areas (PAs) for the assessment of the intangible elements of network conditions (three PAs) and structural components (five PAs). Each process area includes various attributes and maturity levels for scoring each attribute under evaluation. The structural elements that should be considered in the maturity assessment are strategy and business model, governance, organizational culture, product and service development, and performance management system. These process areas focus on company level and assess the sustainability performance of the core company within a network. The maturity levels for each attribute within the process areas are defined with a questionnaire developed for the assessment (see SustainValue 2013). The questionnaire includes closed questions for each attributes of the process areas. The answer alternatives consist of practices that determine the maturity score and level of the attribute in question. Each attribute consists of maturity levels from 1 to 5, where maturity level 1 indicates low maturity level and the worst practice and maturity level 5 indicates high maturity level and the best practice. The maturity scores of individual attributes within PAs can be summarized to form an integrated score for each PA. These maturity scores for each PA form the maturity profile of the network conditions and structural elements.

Systems dynamics

System dynamics is a well-known modeling methodology and technique that can be used to support policy analysis and design of complex systems. It applies to a wide variety of processes/systems in the context of different types of environment, dealing with complex social, managerial, economic, or ecological problems. System dynamics might be adopted as a "tool" for different tasks at a planning stage of service development, also having proven capabilities for asset life cycle simulation. Moreover, thanks to its modeling flexibility, it would be used with the purpose to analyze various types of relationships in socio-technical problems (see, e.g., the case proposed by Caulfield and Maj (2002) testing Brooks' Law through system dynamics) encountered with new service ideas under development; this would eventually help providing a quantitative assessment to support tasks at the service planning stage and could be carried on at least by using the best guesses of experts, at most basing onsets of data adequate to support accurate quantitative verifications of future service plans. For what concern system dynamics methodology steps, its analysis normally consists of 5 essential steps. First of all, the system or the process under study must be structured, identifying problems of concern, selecting analysis boundaries, and collecting preliminary information and data. Step 2 of the methodology includes the identification of all the variables of the problem and the development of the influence diagrams, which is composed by casual loops between the variables. At this level, the system description is translated into rate equations of a system dynamics model: Creating the simulation model requires that the tasks of step 1 are completed; if in step 2 some gaps and inconsistencies are revealed, those must be remedied stepping back at the prior phase. This feedback scheme occurs at every step, and it follows the casual loop approach of the system dynamics methodology.

In step 3, often named dynamic modeling, a high-level map or systems diagram, showing the main sectors of a potential simulation model, is developed and all the variables are defined as so-called stock or flow (slang in the system dynamics terminology). Step 4 is then used to test various policies and strategies, for example, changing one or more internal variable, in order to identify key drivers of change, eliminate some uncertainties, and simulate different scenarios. Last, step 5 is for evaluation and implementation of changes tested through simulation; in fact, the model will show how the system is causing the troubles that are being encountered and some possible solutions may be presented and applied.

4 Conceptualization of a Possible Path to Sustainable Solutions

Goal of this section is to enable developers to develop sustainable solutions with applicable tools and methods in a value network. As there hundreds of possible tools, also for sustainability engineering (Forbes et al. 2008), it is not expedient to describe all possible tools that would be applicable. According to the gap analysis, performed in Sect. 2 in Chap. "Development Methodology for Sustainable Solutions", the approach of Tukker and Tischner (2004) was one of the most promising procedures to develop sustainable solutions, with an emphasis on sustainable product service systems. In their approach, they describe one "possible path" to sustainability based on 5 steps (Fig. 4). Each of these steps represents main tasks and tools which help to develop sustainable product service systems.

This approach is used as a basis to show a possible development path in the development framework (see Fig. 5 and Sect. 4 in Chap. "Development Methodology for Sustainable Solutions" for details of the development framework).

The work done in the previous sections and the description of useful tools for development of sustainable solutions will be used to provide a guideline for companies and value networks to develop sustainable solutions.

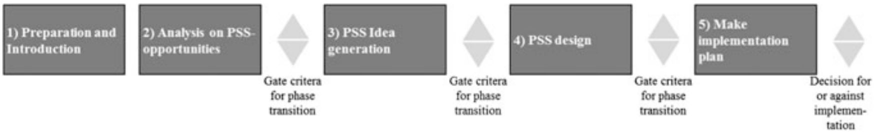

Fig. 4 Five steps of PSS development processes (adapted from Tukker and Tischner 2004)

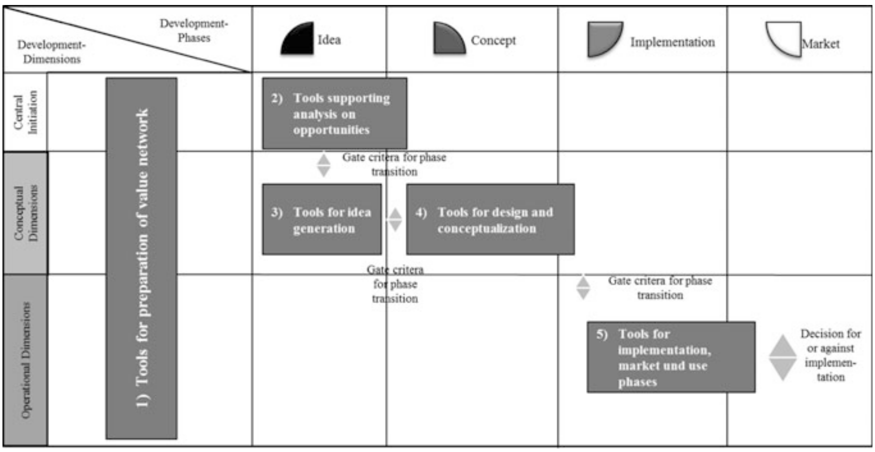

Fig. 5 Steps and tools enhancing the development framework for sustainable solutions

5 Guideline of a Possible Application of Tools

This guideline shall help a developer in a company or value network to develop sustainable solutions based on a possible path and application of relevant tools. Together with the methodologies described in the development framework it allows a holistic development of sustainable solutions. According to Fig. 5, following steps for the guideline are presented:

- Tools for preparation of value network,
- Tools supporting analysis on opportunities,
- Tools for idea generation,
- Tools for design and conceptualization,
- Tools for implementation, market, and use phases.

5.1 Tools for Preparation of Value Network

In the first step, a project plan and a team of the value network should be set up. In particular, it is important at this step, that the relevant stakeholders of the value network and possible users of the sustainable solution are considered during the team setup. The preparation can be initiated from any participants in the value network. Most suitable for an initiator would be a company that will have most stakes in the project. The initiator would invite experts and stakeholders (internally and externally) to discuss the goals and project circumstances. In this step, project planning tools that allow collaborative work shall be used.

Besides this step, the team members should familiarize with the SustainValue project outputs to fully understand the potentials, pitfalls, and possible methodologies leading to sustainability.

5.2 Tools Supporting Analysis on Opportunities

As a first step, priorities have to be made to decide which areas and markets will be most interesting and promising to develop a sustainable solution in. This step often goes along with the step to analyze the current value network and the clients need to identify possible opportunities to be more sustainable. Here, a strategic thinking with holistic tools is necessary to support a sufficient perspective on sustainability that covers all life cycles and stakeholders. In the SustainValue project, many tools have been developed, used, and tested supporting these two first steps.

5.3 *Tools for Idea Generation*

Finding promising ideas is the next step toward creating new sustainable solutions. Based on the approaches described in Sect. 3, the team of stakeholders should work out ideas. The goal is to find as many ideas for sustainable solutions as possible without rejecting any ideas. The evaluation and elimination would take place in a defined procedure later on.

Different tools can be used to generate ideas:

- Tools from the SustainValue project

– Value mapping tool to recognize sustainable opportunities.
– System SWOT analysis, PESTLE/STEEPLED, and Sustainability Continuum.
– Brainstorming supports the generation of new and independent ideas.
– Scenario management tool helps analyzing the different ideas and scenarios found in the brainstorming process,
– Sustainability Impact Calculation Tool (SIC-Tool),
– Maturity assessment model may help to assess ideas for their industrial and sustainable applicability.

- Additional tools (Tukker und Tischner 2004).

– Creativity tools such as Brainstorming, Brainwriting, Roadmapping for finding ideas.
– Sustainability guidelines for supporting the creativity tools.
– An Innovation Matrix for evaluating the most relevant ideas.
– Archetypical models for new value creation.

Describing the ideas is the next important sub step. The name, a short list of key product and service elements, and a design plan sketch of the system should be documented in a simple form. Beside the descriptive information, it is important to create a sustainability rating for every idea to make a comparison possible. The rating should be divided in the three dimensions of sustainability. Answering the questions by rating the product (1 = better, 0 = equal or −1 = worse) helps creating a unique score for each idea (Tukker und Tischner 2004).

Economic/profit aspects

- How profitable/valuable is the solution for the providers (can be a consortium of companies), including cost of product ion, cost of capital and market value of the solution for the provider(s)? Is it cheaper to produce than the competing product?
- How profitable/valuable is the solution for customers/consumers? Are there any concrete, tangible savings in time, material use, etc. for the customer? Does it provide priceless, intangible added value like esteem, experiences for which the customer is willing to pay highly? (both in comparison to a traditional product system).

- How difficult to implement and risky is the solution for the providers? Can a promised result be measured and delivered with a high probability, or has the client a high and uncontrollable influence on the costs? When is the return on investment expected?
- How much does the solution contribute to the ability to sustain value creation in the future? Does it give the consortium that puts the PSS on the market now and in the future a crucial and dominant position in the value chain?

Environmental/planet aspects

- How good is the solution in terms of material efficiency (including inputs and outputs/waste)?
- How good is the solution in terms of energy efficiency (energy input and recovery of energy without transportation)?
- How good is the solution in terms of toxicity (including input/output of hazardous substances and emissions without transport)?
- How good is the solution in terms of transport efficiency (transportation of goods and people including transport distances, transportation means, volume, and packaging?

Social/people aspects

- Does the PSS contribute to quality of work in the production chain (environment, health, safety; enriching the life of workers by giving learning opportunities, etc.)?
- Does the PSS contribute to the "enrichment" of life of users (by giving learning opportunities, enabling, and promoting action rather than passiveness, etc.)?
- Does the PSS contribute to intra- and inter-generation justice (equal wealth and power distribution between societal groups, North–South, not postponing problems to the next generation, etc.)?
- How much does the solution contribute to respect of cultural values add cultural diversity, e.g., customized solutions, contributing to the social wellbeing of communities, and regions (cultural values)?

5.4 Tools for Design and Conceptualization

After generating and evaluating the ideas, the design and conceptualization phase begins. The aim is to develop the idea further from a simple sketch to a detailed description of the product. The first substep is to design the new system structure and to work out the detailed design of the system, how actors interact and how elements in the system fit together. Therefore, the team can utilize following tools (Tukker und Tischner 2004).

- LCC Estimation tool for giving a feel of the life time costs of the solution.
- Sustainability Impact Calculation Tool (SIC-Tool) helps rating the solution regarding its sustainability.
- FMEA—tool helps avoiding failure in the design process.
- Service Blueprinting enables developers to visualize their ideas.
- Supplier evaluation matrix supports the process of finding reliable and sustainable business partners.
- Sustainability guidelines for supporting the design process.
- Draft system map for new system.

– Map activities and material flows.
– Map information flows.
– Map financial flows.

- Interaction story board for visualizing the points of interaction between the actors.
- Stakeholder motivation matrix compares the advantages of different stakeholders working together.

5.5 Tools for Implementation, Market, and Use Phases

After specifying the design and concept of the sustainable solution, the stakeholders have to work out an implementation plan. Therefore, they can make use of a list containing implementation issues related to the go/no-go criteria from the previous phase. If a feasible solution strategy for every implementation issue mentioned is found, the project can move to the next sub step. Before decision making for or against the project, the team should prepare a management presentation that includes every issue regarding the project and summarizes a business plan. Important contents of the presentation are (Tukker und Tischner 2004):

- A striking name (see description of sustainable solution idea documentation).
- Simple visualization that shows the advantages of the project in one image.
- Brief description (see description of idea documentation).

– Description of the context of the strategy (including the following points to consider).
– What is the purpose?
– Which customer segment?
– Why the change? What will it yield? Why is it recommendable?
– Why does it fit in with the company, what policy does it fit in with? Marketing Mix.

- Marketing Mix

- Product service description: Brief description of the solution.
- Price: What pricing strategy will you adopt to reach the customer segment?
- Promotion: How are you going to let customers know what you are supplying?
- Place (sales channels): How are you going to sell the sustainable solution (via Internet, directly to the customer, call centers).

- Expected result regarding financial, customer and brand issues

- What do you expect from this strategy in terms of: turnover, profit, market share, value creation, return on investment, customer loyalty, brand awareness, promotion, positioning, etc. (as far as possible give specific and concrete results).

- Advantages and Risks of the solution

- Primary target group: Briefly describe the primary target group in the customer segment.
- Positioning: What Unique Selling Points does the solution add?
- Creative Approach: In what creative way will you target the market (what is the key to success?)
- Drivers and obstacles: Which drivers promote the new solution, which risks and difficulties do you have to overcome? What does the success of the strategy depend on? What are the bottlenecks and uncertainties?

- The Investment needed

- What is needed to implement the strategy and to neutralize uncertainties and bottlenecks in terms of money, people, resources, time, R&D, strategic alliances, etc. Demonstrate what the new strategy will mean for the company.

- Next steps toward implementation including timing, needed actors.

At the end, the management should have enough information to be able to make a decision for or against the sustainable project.

6 Conclusions

The review of literature as well as the engineering practice to date reveals a lot of methods and tools that assist organizations to develop and optimize their business processes. Nevertheless, due to actual economic, environmental, and societal challenges, economic agents are confronted with the necessity to increase the sustainability of their products and processes. Key challenges that sustainable manufacturing must meet are economic challenges, by producing effectively and efficiently and creating new services ensuring development and competitiveness through time. Moreover, environmental challenges have to be faced, e.g., by promoting minimal use of natural resources (in particular non-renewable energy) and managing them in the best possible way while reducing environmental impact. Furthermore, existing societal challenges have to be taken care of by promoting social development and improved quality of life through renewed quality of wealth and jobs. Thereby, a useful tool and method box, which allow the development of sustainable solutions and processes, are lacking.

Hence, the main achievement of this chapter is a detailed toolbox, which companies can use by implementing the development methodology for sustainable solutions developed in this project, respectively, by analyzing and optimizing their processes in order to increase the sustainability. The identified tools corresponding to the requirements from the project context were categorized according to the structure of the methodology: central initiation, conceptual dimension, and operational dimension. A separate category of tools includes tools and techniques for the application in all dimensions.

Additionally, this chapter shows a possible development path and the suitable tools for application, which can be used as a guideline for companies and value networks to evaluate and optimize their current business processes. Together with the methodologies described in the deliverable Sect. 4 in Chap. "Development Methodology for Sustainable Solutions" the presented toolbox helps "a developer" in a company or value network to develop sustainable solutions.

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Part IV
Performance Management in Sustainable Manufacturing Networks

Dynamic Drivers of Modern Performance: Values, Stakeholders, and Resources

Jayantha P. Liyanage

1 Introduction

In response to existing uncertainties, complexities, and the dynamism of global economic activity, many changes have begun to appear in both public and private sector organizations. The biggest debate by far appears to relate to governing economic regimes.

> Capital markets and venture capital firms have arguably altered the economic rules for ever. (Buckingham 2001, p. 39)

Furthermore, as the new global economy forces the *public* to redefine the place of an organization in a socioeconomic setting, misconduct and mistrust have begun to show a greater potential to cause an enterprise to *fail* (Hickman and Silva 1987). Those who fail to show ethically and socially responsible behavior are exposed to a greater potential to lose their competitive edge as they betray the trust of employees, customers, government agencies, and even competitors. Abrahams (2001) notes that people no longer see the accumulation of wealth and the maximizing of profit as the only measure of success.

> Loss of quality and integrity are not only regrettable but also reprehensible. (Abrahams 2001, p. 63)

The aggressive promotion of sustainable strategies seems to offer organizations the opportunity and the challenge to more broadly define business interests, extending their obligations beyond shareholders to include *others* to strengthen their position (Armstrong 1994). Russo and Fouts (1997) observe that such relational strategies constitute a competitive advantage, particularly in high-growth industries (Armstrong 1994; Stultz-Karim 1995; Abbott 2001).

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In principle, prevailing ideologies about sustainability revolve around a blend of economy and technology; ecology and demography; and governance and equity (World Business Council for Sustainable Development 2001). It raises a culture of *core values* constituting of human dignity, environmental stewardship, health and safety, valuing others, business ethics, economic prosperity, and so on. This in turn raises fundamental questions for the global business sector regarding how to come to terms with the challenges of the twenty-first century, i.e., dealing with a changing value system, which is in continuous tension, and subsequent uncertainties. By having sustainable growth as an underlying platform for global business activity, businesses can seek unique advantages for continuous business development. This involves a process of resolution through collaboration, i.e., as Gray and Wood (1991) highlight, a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible. It underlines the principal fact that sustainable movement requires that all parties satisfy their own needs (Garcia and Vredenburg 2002).

Bringing further light onto this endeavor, some of the scholarly work concludes that those sustainable strategies also complement the financial performance of organizations (see for instance Cochran and Wood 1984; McGuire et al. 1988; Waddock and Graves 1997, etc.). Furthermore, a more recent study carried out by Innovest Strategic Value Advisors Inc. (2002) on corporate environmental positioning indicated that those leading organizations which resorted to sustainable business posted superior financial results. By analyzing the performance of 17 integrated organizations, the report examined the extent to which environmental, social, and political factors influence the generation and protection of shareholder value. The analysts point out that this provides strong evidence of the financial merits of sustainable business leadership and, moreover, that poor environmental and social practices have a material bearing on risk level and have negative effects on financial performance and thus on shareholder value (see Kieran 2002, etc.).

Competitive advantage arises in light of sustainable strategies as they involve building superior capabilities in managing *external relationships* (Hart 1995; Stead and Stead 1996). Elaborating on the *stakeholder theory*, Freeman (1984) asserts that firms have relationships with many constituent groups and that these stakeholders both affect and are affected by the actions of the firm. The basis for such relationships between *sustainable business* and *sustainable socioeconomic growth* is *dual*. Such strategic relationships can grow as organizations devote their *resources* to improving the economy, environment, and society in an integrated way to fulfill their responsibilities toward multiple stakeholders at various levels, i.e., economic, legal, ethical, and philanthropic (Carroll 1991; McWilliams and Siegel 2001). By so doing, organizations can aim to capitalize on the various opportunities that those relationships and recognition create and to mitigate potential risks to enhance global business activity. This implies that a growing number of businesses have begun to understand that emerging waves of interest and increasing *public* awareness on *sustainable socioeconomic growth* can directly or indirectly influence business value (Armstrong 1994; Browne 1998; Bradely and Hartog 2000). This in turn demands a fundamental shift in the business regime from being a pure profit-seeking one, to one where the *legitimacy* of such profit-seeking processes is rendered as a survival and growth strategy. It appears that this transition entails some form of a novel *value proposition* for business performance in respect of commercial success, owing to the existing tension that extends beyond the traditional financial boarders of organizations, i.e.

> *It* raises a fundamental extension in managerial objectives beyond shareowners and towards the interests of all stakeholders in light of organizations' performance. (Donaldson and Preston 1995, p. 80; italics added)

The modern value proposition in the global business sector appears to greatly involve some form of *relationships* (or *contracts* as Freeman and Even 1990; Atkinson et al. 1997, call them) based on new needs and expectations that challenge the conventional wisdom and fundamentals on corporate governance and business performance management. New insights and theoretical underpinnings on this mostly appear to revolve around *value shift, stakes and stakeholders*, and *resources and capabilities* as three major regulating factors of performance dynamics.

2 The Value Shift

As the notion of *corporate imperialism* has greatly been challenged by the dynamics, complexities, and uncertainties in global business environments, organizations are more compelled to rethink how they do business and how to reconfigure their business models (Prahalad and Lieberthal 1999). A more convincing argument is the comparison between the market value of an organization and the net value of its physical assets in financial terms. It is said that almost 80 % of value created in stock markets today is not accounted for on organizational balance sheets (see Green 2000; Webber 2000; Kaplan and Norton 2001a; Petroleum economist 2001); i.e., there are clear market potentials to redefine what truly are the *values* of an organization.

> We spend a great amount of time identifying and quantifying the company's genuine assets…the real gems are…almost never listed on a balance sheet or anywhere else in the financial statements. (Litman 2000, p. 38)

This underlines two interesting issues, i.e., first, the stock market increasingly takes account of other sources as bases of valuation than those offered by traditional financial reporting (see Clarke 2001), and secondly, capital market analysts look into two sources of value, for instance, the value of its future growth options as much as the net present value of an existing business (see Townley 2000). In principle, it emphasizes on the inadequacy of loss-profit accounts or balance sheets:

> There are growing doubts whether existing financial reporting systems can meet the changing information needs of business and society. The president of the Institute of Charted Accountants in England and Wales…has posed these dilemmas…what is a

> company worth? Accountants all know that a balance sheet is not a guide to value. What are a company's prospects? All accountants know that an historical profit and loss account is not necessarily a guide to sustainable earnings. What risks does a company face? Accountants all know that accounts do not deal explicitly with risks. What are a company's intangible assets (let alone what they worth)? Accountants know that accounts do not speculate in such matters. (Clarke 2001, pp. 16–17)

Secondly, it also emphasizes the economically non-expressible *value* of intangible assets:

> Assets used to be thought of as something you own, control, and can touch, and 30 years ago these assets made up 99% of a company's market value. But in the new economy, intangible assets, encompassing things you don't own, such as relationships, brand, and leadership, generate as much, if not more, economic value for your business. (Petroleum Economist 2001, p. 28)

It gradually becomes a widely known fact that non-financial aspects, or intangibles, are known to play an important role in business settings. Not only do they constitute the *hidden values* of an organization, but they also provide an indication of the *future growth* of a business (where traditional accounting mostly fails) and hence define its competitive strength (Alexander and Low 1997; Visser and Williams 2001; Edvinsson and Malone 1997; Freedman and Cole 2000; PricewaterhouseCoopers 2000). As many scholars argue, traditional budgeting and accounting systems—which are aimed at satisfying what are termed *Wall Street Desires* with the potential for manipulations—are incapable of coping with new demands and unable to reflect the true value since such accounting is meant to address more tangible aspects (Itami and Roehl 1987; Barney 1991; Mills 2001; Hillman and Keim 2001; Hope and Fraser 2001; Visser and Williams 2001). Formally, valuation is a financial skill that has greatly been challenged as financial markets have collectively decided that an organization's physical assets are less valuable than confidence in how those assets can be put to use. At the same time, investors look beyond traditional financial measures to visualize an organization's value, as it is widely acknowledged that today's profitability has to be complemented by future growth, and they have begun to reward those organizations which pay increasing attention to intangibles, (Brunetto and Yacko 2000; Kaplan and Norton 2001a; PricewaterhouseCoopers 2000; Visser and Williams 2001, etc.). This has two direct implications, i.e., the increasing sensitivity of non-financial measures and the redefinition of traditional organizational values.

In general, financial accounting is constrained by law and convention, as Atkinson et al. (1997) note, Nordberg (2001), etc., and it still does what it was meant to do, i.e., to give a reasonably accurate snapshot of the business; this remains an important requisite for the audit to be sure that organizations do not *cook the books*. At the same time, there is a growing recognition that conventional profits and loss accounts create greater tendencies to hide key risks. Although past performance captured in financial reporting helps in developing trust, for many industries it has become less relevant to the prediction of future growth.

> We see this in the rise of interest in reporting intangible sources of value, and in the growing interest – among regulators and investors – in risk management…looking at this from the investor viewpoint, the faster the pace of change, the faster the decline in the value (*in fact importance*) of historical financial information as an indicator of future performance. (Nordberg 2001, pp. 32–36. italics *added*)

Hence, as constantly noted by Kaplan and Norton (1992, 2001b), exclusive reliance on financial indicators could promote behavior that sacrifices long-term value creation for short-term performance. It also pays attention to the fact that long-term economic prosperity is based on intangible sources of value rather than on the fixed assets and that a major share of the value of a business has always rested more in its current potential than in its past. However, importantly, this value cannot be separated from the organizational processes that transform intangibles into business outcomes (Penrose 1959; Barney 1991; Drucker 1993; Teece 1998, etc.). For instance:

> Some argue that companies should follow the same cost-based convention for their intangible assets, i.e. capitalize and subsequently amortize the expenditure…but such costs are poor approximations of the realizable value created by investing in these intangible assets. Intangible assets can create value for organizations, but that does not imply that they have separable market values…the value of an intangible asset depends critically on the context, i.e. the organization, strategy and other complementary assets, in which an intangible asset is deployed…the value does not reside in any intangible asset. It arises from creating the entire set of assets along with a strategy that links them together. The value creation process is multiplicative, not additive. (Kaplan and Norton 2001a, p. 89)

In light of the rising importance of intangible assets, and the growing emphasis on strategy, management quality in investment decisions, etc., Nordberg (2001) argues that *we've drawn the definition of what is material too narrowly*. Further, Allen (2001) argues that, unless the value of intangibles (together with tangibles) is appropriately incorporated, an organization's balance sheet will not indicate the true worth of the business. Hence, as Bauschka (2000) notes, an intimate understanding of sources of value in an organization and how each business unit delivers that value, i.e., understanding value-creating potential, remains critical to achieving superior performance. However, Visser and Williams (2001, p. 1) note:

> Managers seeking guidance as to what is of value in their businesses find themselves in a complex field. Perhaps there has never been more voluble criticism about traditional methods of valuing a business. These range from criticism about the way in which traditional financial indices of value can be manipulated, to complaints about the lack of attention paid to some fundamental drivers of organizational performance.

Hence, it is worth exploring values and their potential to understand the hidden impact on performance in relation to the current popular wave.

2.1 What Are Values?

Increasing attention and growing interest on this subject have lent themselves to a number of interesting insights. For instance, in their study to examine relations between organizational values system and the productivity of service workers, Dobni et al. (2000) specify 31 statements in the taxonomy of organizational value systems in terms of *employee, competitive, customer, operational, organizational, change*, and *social aspects*. Hall (1995) presents 125 corporate value definitions in relation to his studies that sought to measure the corporate value system, comparing it to departmental, group, and individual values. Herz (2000), on the other hand, insisting on a new value reporting framework (i.e., a framework designed to bridge the information gap between management's understanding of a company's value drivers and the financial community's need for this insight), embarked on a business value platform that is composed of six key value drivers (i.e., *innovation, brands, customers, supply chain efficiency, people*, and *reputation*) that must be actively managed to optimize shareholder value.

In principle, many efforts use various perspectives and diverse terms (e.g., *value added, value creation, value extraction*, and so on) to explain the underlying logic and dynamics of performance. For instance, according to Quinn and Rohrbaugh (1983), one of the major problems to date is that values have never been clear. They observe that the criteria that organizational theorists and researchers use to evaluate the performance of organizations underline four models of value orientation (i.e., *rational goal, internal process, open system*, and *human relations*). They each have varying value propositions, ranging from, for instance, planning, objective setting, information, communication, and so on to flexibility, resource acquisition, morale, etc.

> These terms are often used with minimal precision and the logic underlying them is fuzzy even if institutively appealing. (Sweet 2001, p 71)

In retrospect, the term *values* can often be seen applied in different contexts. One of the applications has a behavioral basis, i.e., values are seen as critical agents that guide and dictate behavior, leading to clear transformations within people and organizations:

> Just as personal values define what individuals consider to be intrinsically desirable and guide their actions and judgments to these ends, organizational values play an important guiding and directing role in the functioning of the organization. (Dobni et al. 2000, pp. 91–92)

Such behavior is contingent on a value shift on the basis of internalization and choice-making as people are exposed to sociopolitical, technological, cultural, and even educational transformations. This also appears to have some links to the notion that values have a moral and ethical basis (e.g., respect for human dignity, respect for basic rights, good citizenship) (see for instance, Griseri 1998).

> 'The core values establish a moral compass for business practice. They can help companies identify practices that are acceptable and those that are intolerable.' (Donaldson 1996, p. 54)

Values are also considered as ideals that are proxies for sociocultural settings:

> Values are ideals that give significance to our lives, that are reflected through the priorities that we choose, and that we act on consistently and repeatedly. (Hall 1995, p. 21)

In financial terms, value is often considered as the difference between earnings and expenses, after tax and cost of capital. But, Townley (2000), Yu-lee and Lorenzl (2001), etc. argue that value is more tied to the strategy and intangibles than to the more traditional economic or accounting definition of value. Thus, Jones (1997) insists that values are characteristics and outputs that actually matter to the business, and thus, they describe the outlook of the organization. Adding to this furthermore, Robinson and Nemrava (2000) contend that value is also contained in the function of the ability to generate future income. This interestingly is more inclined to visualize that values are

> *means* as well as *ends*.

In a broader perspective, this notion in particular is consistent with current literature on *resource-based* and *stakeholder* theories.

3 Stakes and Stakeholders

Dafel and Jackson (2000) note that organizations are social systems that emulate living organisms in many ways. The successful ones adapt to changes in their environment.

> Today's world is not about the survival of the fittest. Rather, it's about the survival of those who fit-in…and hence…the approach you adapt must be suited to the pace of change… (Dafel and Jackson 2000, p. 37)

Dealing effectively with financial, environmental, and social issues now requires organizations to communicate with many groups affected by their operations. This involves some form of interaction with them on a relational or contractual basis to deal with the turbulence and complexity of their environment (Garcia and Vredenburg 2002). Such a relationship is made up of expectations about the behavior that satisfies some form of requirement. It constitutes an engagement of trust, commitment to stay in relationships, willingness to put some effort into maintaining the quality, and an *active allegiance*, i.e., behaving positively toward the other agent, as an appreciation of that behavior (MacMillan et al. 2000). Technology and globalization have contributed much in making such networks of relationships strategically important and, moreover, a more decisive intangible asset for organizational performance than ever before (Svendsen et al. 2001). As the link between stakeholder relationships and business success has drawn much attention, *the move toward sustainability* in particular calls for a better understanding on the management of such new relationships with organizational stakeholders (Svendsen et al. 2001; Agbon 2001).

The stakeholder concept still remains relatively vague, varying from broad to narrow in discussions and applications (Mitchell et al. 1997; Jones and Wicks 1999). The narrow view defines them in terms of their direct relevance to organizations' core economic interests, and the broad view, in contrast, takes into account almost anyone that organizations can vitally affect or can be affected by.

In principle, any insight into stakeholders or to the respective theory for that matter is based on two fundamental concerns (see Freeman 1984; Mitchell et al. 1997), i.e., what stake (i.e., *what counts*) and who holds it (i.e., *who counts*). According to Donaldson and Preston (1995), a *stake* constitutes some form of a *right* in the affairs of the organization, incorporating a need, ability, effort, and/or mutual agreement.

> For example the stake of long-term employees who have worked to build and maintain a successful business operation is essentially based on effort. The stake of people living in the surrounding community may be based on their need…customer stakes are based on the satisfaction and protections…and so on. (Donaldson and Preston 1995, pp. 84–85)

Stakeholders are defined as groups or individuals who can affect or are affected by the achievement of the organization's objectives (Freeman 1984), without whose support the organization would cease to exist or on which the organization is dependent for its continued survival (Stanford Research Institute, 1963, as quoted by Freeman 1984; Clarkson 1995), to whom a firm is responsible (Alkhafaji 1989), and those in relationship with an organization (Atkinson et al. 1997; MacMillan et al. 2000).

Stakeholders can be identified through the actual or potential harms and benefits that they experience or anticipate experiencing as a result of an organization's actions or inactions (Donaldson and Preston 1995). And, furthermore, they can also be identified through the nature and the magnitude of the impact of response from those groups and institutions on the commercial activity of the business. The actual stakeholders of an organization, however, according to Mitchell et al. (1997), Harvey and Schaefer (2001), possess at least one of the three attributes;

- *power* (to influence business activities),
- *legitimacy* (of the relationship for transactions), and
- *urgency* (of their claims requiring serious actions).

Others may fail to receive the attention of management, regardless of how well justified their demands may be.

> Stakeholders that have no power to impose sanctions on companies are not perceived to be legitimate – which may just mean that they are non-traditional,…or who don't shout very loud and totally ignored…and their claims are not likely to be treated with the same seriousness. (Mitchell et al. 1997, p. 254)

Prior to 1960, as Agbon (2001) notes, the major stakeholders of a business simply were the organization and shareholders. But the formation of independent watchdogs, the growth of environmental and social movements, as well as the voice of indigenous communities, forced many sensitive industrial sectors to recognize governments and host communities as major stakeholders. Furthermore, those stakeholders nowadays also incorporate customers, employees, suppliers non-governmental organizations, local communities, governments, social activists, competitors, etc. (see Freeman 1984; Armstrong 1994; Tomei 1998, etc.). These groups have the potential to influence risks as well as opportunities implicitly or explicitly, after having invested some form of *capital*, human, financial, or something of *value*, in a firm (Hillman and Keim 2001) or being exposed to the potential of losing something of value as a result of business action. It implies that apart from those who are in direct transaction with the organizations, there are those regarded as stakeholders who provide infrastructures and markets, and even further who share common natural resources. The central advocacy of stakeholder theorists is that organizations should redefine their purpose, in the view that such a purpose is to serve as a vehicle for coordinating the core interests of those influential and dependent stakeholders (Freeman and Even 1990; Donaldson and Preston 1995).

According to Hillman and Keim (2001), stakeholder theory can be viewed in relation to a set of interdependent relationships among stakeholders that exits on economic, social, and/or ethical grounds. Thus, for instance, as Donaldson and Preston (1995), Mitchell et al. (1997), Jones and Wicks (1999), etc. elaborate, it intends both to explain and to guide the structure and operations of organizations on the grounds of

- *the descriptive,* used to describe and sometimes explain specific organizational characteristics and behaviors,
- *instrumental* attempts to identify the connections between stakeholder management and the achievement of organizational objectives linked to profitability, growth, survivability, etc., or
- *the normative* interprets the functions of the organization on the premise of moral or ethical guidelines.

For instance, according to Donaldson and Preston (1995):

> The *normative* for these changes in current mainstream legal thinking is articulated in the recent *American Law Institute* report, *Principles of Corporate Governance* (1992)…the modern corporation by its nature creates interdependences with a variety of groups with whom the corporation has a legitimate concern… (Donaldson and Preston 1995, p. 82)

Those studies that address the *instrumental* basis in particular mainly look into socioeconomic aspects of stakeholder theory and advocate that adherence to stakeholder principles and practices is instrumental to achieving desired organizational objectives (e.g., Aupperle et al. 1985; Cochran and Wood 1984; Cornell and Shapiro 1987; Preston and Sapienza 1990; Kotter and Hesket 1992, etc.). It thus is inclined to explore the logic as to how organizations can succeed in the current and future business environment by inducing constructive contributions from those stakeholders to accomplish desired results, resting on a formal or institutionalized basis, an economic basis, or a social legitimacy basis (Freeman 1984).

3.1 Agents and Conflicting Interests

In general, stakeholder orientation and subsequently its theoretical underpinnings can be explained in view of three principal theories in respect of the presence of some form of bargaining power and associated risks and opportunities (also see Eisenhardt 1989; Pfeffer 1981; Jones and Hill 1988; Mitchell et al. 1997; Atkinson et al. 1997), i.e.

- *agency* (attend to those stakeholders having the power)
- *resource-based* (possession of resource power makes the stakeholders important to managers), and
- *transaction cost* (stakeholders outside the firm boundary who participate in a very small competitive set can increase transaction costs to levels that justify their absorption into the firm)

The relationship between an organization and its stakeholders can be conceptualized in terms of *agency theory*, where firms can be seen as a bundle of contracts with stakeholders either on economic or social legitimacy grounds (Freeman and Even 1990; Hill and Jones 1992; Woodward et al. 1996; Harvey and Schaefer 2001). *Agents* are the units who interact and affect each other through their chosen actions, and action chosen by one agent may affect the actions of other agents through constraints, expectations, and preferences. The notion of an agent embraces persons, firms, and other entities, such as non-profit organizations and governments. The essential characteristic of an agent is not its physical form but rather lies in the status as a decision-maker who affects the others (Manski 2000). According to Eisenhardt (1989), agency theory is concerned with resolving problems that can occur in agency relationships, i.e., the conflicts in desires or goals between the principal and the agent, and furthermore, it is difficult or expensive for the principal to verify or cope with what the agents are actually doing. Here, the problem, as noted by Clarkson (1994), mainly lies in the risk-based differences in terms of agent's perception, attitude, exposure, and underlying preferences for actions.

In general, advances in information and communication technologies have certainly contributed to narrowing the physical distance of actual events from stakeholders, as well as the gap in terms of access to information. Furthermore, governments become more sensitive and responsive to the pressure of independently active groups. The latter, as Tomei (1998) notes, in fact have proven very skillful and effective in lobbying and mobilizing societal pressure on government and legislations. Moreover, through public campaigns, networking, and lobbying, those groups have been able to substantially influence the implementation of business development activities. This has impacted many organizations, not only by causing serious financial losses or additional expenses, but also on the image.

As noted, for instance, by Rowley (1997), stakeholder influence is no longer determined solely by the attributes of individual groups but also by the way in which different stakeholder groups interact and form networks. They may differ in terms of constituency, agendas, goals, and organizational structures, but do, however, share a common concern: i.e., to prevent adverse environmental and social impacts of business operations (Tomei 1998), through collective efforts to address problems when they become too complex to resolve (Gray and Wood 1991). In resolving conflicting interests with stakeholders, organizations appear to resort to stakeholder consultation and information (see Polonsky 1995; Clarkson 1995; Mitchell et al. 1997; Harvey and Schaefer 2001). In accordance with Dafel and Jackson (2000), it can be seen as an effective strategy to manage potential risk and to add value by tapping into the wisdom of influential parties. Furthermore, stakeholder dialog, i.e., consulting those groups affected by an organization's actions, has been developed as a part of the modern approach to social auditing, underlines Cumming (2001), which aims at seeking the judgments of those who are most affected by an organization's actions. Therefore, organizations assimilate information from many perspectives, benefiting from the diversity of views that emerge to create a successful organization through strategic planning. Such a systematic process more formally constitutes the identification of relevant stakeholder groups, determining the stake and the importance, how effectively their expectations have been met, and the modifications to corporate policies and procedures to meet their interests (Freeman 1984). In light of all the differences and tensions, organizations attempt more and more to use some performance assessment systems to monitor those contractual relationships (Atkinson et al. 1997).

3.2 Impact on Performance

Some argue that it is possible to analyze and evaluate an organization's performance partly by looking at the way in which it manages relationships with its stakeholders. This rests on the comprehension that identification and management of stakeholders are gaining momentum and acknowledgment as an increasingly vital challenge for any organization's successful performance today (see for instance Savage et al. 1991; Wood 1991; Clarkson 1995). This is based on the notion that:

> Increased competition encourages firms to search for sources of organizational advantage that cannot easily be quickly duplicated in order to continue to attract investment capital… organizational advantage may be built with tacit assets that derive from developing relationships with key stakeholders… (Hillman and Keim 2001, p. 135)

It was asserted that, if the activity is directly tied to primary stakeholders, then investments may benefit not only stakeholders but also result in increased shareholder wealth; i.e., effective stakeholder management through the devotion of resources, competencies, and capabilities complements shareholder value, and failure to do so creates shareholder risk (Jones 1995; Atkinson et al. 1997). Moreover, strong relationships are considered to be a prerequisite for innovation, help build a good reputation, etc. and, more importantly, are said to provide better access to important resources (e.g., talent, creative financing) necessary to stay in business. For instance:

> Business needs successful relationships with individuals and organizations in order to thrive. People need to be keen to buy from, work for, supply to, and invest in a business. This is how a business gains the necessary resources it needs to survive and prosper. (MacMillan et al. 2000, p. 69)

This is particularly the case for knowledge and intellectual capital (Nahapiet and Ghoshal 1998; Kay 1993) and even for employee satisfaction and retention, which are considered important outcomes of the successful relationships that a business has with its stakeholders. Employee satisfaction in particular, as Svendsen et al. (2001) note, is an important intangible asset that an organization cannot afford to ignore and that has been proven to have business value. Within relationships resides social capital that is meant to bring the benefits or resources that accrue to a business from a network of such relationships. This involves an exchange process, for instance, information, knowledge, experience, satisfaction, emotions, and incentives. In competitive terms, the strategic importance of those intangible resources and the capabilities they nurture lies in the social complexity and path dependency that enhance an organization's ability to outperform competitors in terms of long-term success (also see Svendsen et al. 2001; Hillman and Keim 2001). This implies that, according to, for instance, Hutton (1999), these assets derived from strong business relationships and partnerships represent the bulk of strengths and opportunities that differentiate an organization from competitors, leading to superior returns or enhancing shareholder value today. It is the reciprocal relationship or impact between organizations and those who can influence it (Donaldson and Preston 1995; Atkinson et al. 1997; Mitchell et al. 1997) that makes a difference.

4 Resource-based Theory

The most powerful way for organizations to survive and grow amidst global competition is still not completely visible to many. For instance, according to Holbrook et al. (2000, p. 1018):

> One of the primary concerns of organizational researchers is how one situation can differ from another in terms of performance, and what are the sources that contribute to such a difference in behavior.

Subsequent attempts to develop a theory of the organization have lent themselves to explore the attributes of existence and performance differences on the presumption that understanding the strategy and performance of the organization is better when one explores the distinctive and idiosyncratic characteristics of an organization's resources (Penrose 1959; Rumelt 1984; Holmstrom and Tirole 1989; Prahalad and Hamel 1990; Montgomery 1995; Conner and Prahalad 1996; Vicente-Lorente 2001; etc.). Historically in fact, the idea of looking at organizations as a broader set of resources goes back to the work of Penrose (1959).

4.1 Theory

The theory of RBV (resource-based view of the firm) advocates that an organization can be conceptualized as a bundle of resources that are exploitable for implementing value-creating strategies and that performance differences across those organizations can be attributed to variances in the organization's resources and capabilities (Wernerfelt 1984; Barney 1991; Collis and Montgomery 1995; Lewis and Gregory 1994; Eisenhardt and Martin 2000; Hitt et al. 2001, etc.). For instance:

> *RBV was shaped by the suggestion that the strategic actions which reposition the firm require it to possess very specific resources,* competences, and capabilities. (Spender 1996, p. 46; italics added)

According to Barney (1991), RBV emerged on the notion that much strategic research has paid attention to the impact of an *organization's environment* on its competitive position and that little emphasis has been placed on the impact of idiosyncratic *organizational attributes* on the same. Thus, more formally, research on organizational resources was meant to examine the link between an organization's internal characteristics and its performance, particularly focusing on the notion that heterogeneity and immobility of resources are possible sources of advantage in competition. Hence, it tended to look at resources from a much broader perspective as involving all organizational attributes (physical, human, and organizational), i.e., *all inclusive,*[1] that enable organizations to conceive of and implement value-creating strategies that improve their efficiency and effectiveness. However, there have been some recent attempts to identify what is actually implied by resources. Apart from its emphasis on the critical importance of internal resources and arguments that organizational performance is a function of how well managers build their organizations around resources, it further draws attention to the impact of various other aspects, e.g., strategic planning, information systems, and intangibles (e.g., reputation), on an organization's competitivity (Barney 1997, King and Zeithaml 2001).

[1]For instance, Barney (1991) uses the term "resources" to include all assets, capabilities, organizational processes, firm attributes, information, and knowledge, controlled by an organization.

4.2 Salient Features

Early contributions in this area (e.g., Wernerfelt 1984; Prahalad and Hamel 1990, etc.) mainly portrayed competitivity as rooted inside the firm, i.e., in internal resources and competencies and in capabilities, which must be deployed to produce superior performance. As this continued to gain much popularity among various scholars and disciplines, inclusive of human resource management, management information systems, marketing, knowledge-based theories of competitive advantage, etc. (see Barney 2001), a few salient features emerged. Firstly, extending beyond the acknowledgment that an organization's value-creating strategies are contingent upon its unique resources, competences, and capabilities, scholars began to pay much attention to stressing the importance of softer aspects or *intangibles*, on the presumption that the best of the resources that lead to superior performance and advantage in competition are more often intangible than physical (see Collis and Montgomery 1995; Petts 1997; Holbrook et al. 2000, etc.). For instance, according to Teece (1998, p. 77):

> There is no such thing as privileged product market position unless it rests on some upstream intangible assets. The focus of strategy analysis must change, and is changing, as indicated by the burgeoning literature in strategic management on the resource-based theory of the firm.

Interestingly, this wave was furthered by some of the scholars toward a *knowledge-based view*, arguing that (also see Teece 1998; Kale et al. 2002, etc.):

> Since the origins of all tangible resources lie outside the firm, it follows that competitive advantage is more likely to arise from the intangible firm-specific knowledge which enables it to add value. (Spender 1996, p. 46)

Secondly, resource-based research work has also been appraised to shed some light on the attempt to explain the financial impact of corporate environmental and social performance by bringing this perspective into the external environment, again upon the recognition of the importance of intangibles (Russo and Fouts 1997).

4.3 Intangibles

Those intangibles that often are subjected to vivid reviews and discussions can more formally be seen belonging to *emotional* (attraction, attachment, satisfaction, motivation, etc.), *relational* (partnerships, alliancing, networking, etc.), and *institutional* (knowledge, information, innovation, image, etc.) aspects. Among many, the latter in particular has received greater attention recently among scholars, leading to organizational performance being viewed in respect of the knowledge at its disposal.

A knowledge-based view is the essence of a resource-based perspective in the sense that privately held knowledge, as opposed to public knowledge, is the basic source of advantage in competition, particularly owing to information and knowledge asymmetries that exist between organizations (Conner and Prahalad 1996). In fact, knowledge of markets, events, and technology has always been crucial to business, and the organization's information-gathering and processing abilities have always been seen as a significant means of strategic competition. This can be seen captured in such literal work as *business intelligence, competitive intelligence,* or *intelligence advantage* (Quinn 1992; McGonagle and Vella 1993; McMaster 1995; Spender 1996, etc.). In these studies, scholars have been paying greater attention to knowledge, its form of existence, and flow within organizational settings. Spender (1996) views this move as a major paradigm shift, as it responds to changes in the economy at large, in a similar way to that in which the industrial age gave way to the information age.

> Instead of treating managers as rule-makers and employees as rule-followers, and firms as bundles of tangible resources, we need a different kind of knowledge-based theory in which organizations are enduring alliances between independent knowledge-creating entities, be they individuals, teams or other organizations, and tangible resources are subordinated to the service they provide. (Spender 1996, p. 47)

Subsequent theory that idealizes an organization as a repository of knowledge seeks to explain the relationship between the knowledge and organizational performance. This stresses that the essence of the organization is contingent on creating, transferring, assembling, integrating, and exploiting knowledge assets and that such individually and organizationally held knowledge is a basis of creating organization-level capabilities that acts as a source of competitive advantage (see Spender 1996; Conner and Prahalad 1996; Grant 1996; Teece 1998; Kale et al. 2002). The process of capability development in the knowledge-based view is more effective, as Kale et al. (2002) say, when there are mechanisms or routines designed to accumulate, store, integrate, and diffuse knowledge. The latter is termed *combinative capabilities* (Zander and Kogut 1995), where individual and group knowledge within the organizational processes are structured, integrated, and coordinated. This move appears to pay great tribute to individuals or knowledge workers, the application of whose privately held knowledge directly affects business activity, information and its technology, experience, and organizational learning, etc.

> The new information technology is also dramatically assisting in the shaping of information. Learning and experience can be much more readily captured and shared. Knowledge learned in the organization can be catalogued and transferred to other applications within and across organizations and geographically…these developments suggest a different dynamic to competition and competitive advantage…competitive advantage at the level of the firm can flow only from ownership and successful deployment of non-tradable assets, i.e. knowledge and other competencies…it is in this environment that a critical dimension of knowledge management has emerged, capturing value from innovative activity… (Teece 1998, pp. 60–62)

Importantly, both the resource-based and knowledge-based views are targeted attempts, as Spender (1996) highlights, to *deconstruct the black box of the economist's production function* (or value-adding process) into some more elemental components and interactions.

4.4 Contribution to Results

RBV has brought an important insight into organizations in terms of understanding which internal aspects lead to superior performance and thus how competitive advantage is achieved (Penrose 1959; Wernerfelt 1984; Barney 1997; Peteraf 1993; Eisenhardt and Martin 2000). The principle assertion is that achieving superior performance, and thus outsmarting competitors, appeals more to developing a competitively distinct set of resources, competences, and capabilities and deploying them in well-conceived *strategies* (Andrews 1980; Wright et al. 1995; Collis and Montgomery 1995; Campbell and Luchs 1997). Organizations can reap the benefits by specializing themselves in respect of specific needs by making them valuable, inimitable or less replicable, rare, imperfectly mobile or less transferable, opaque or less transparent, and durable (Barney 1991; Grant 1991; Peteraf 1993; Foss et al. 1995; Vicente-Lorente 2001, etc.). This is where intangibles (e.g., knowledge-based or human resource-related) are mostly seen as central to value-creating processes, since they are said to be *socially complex* and generally follow tacit and complex routines (i.e., *causally ambiguous*) (Itami and Roehl 1987; Peteraf 1993; Teece 1998; Lepak and Snell 1999; Hitt et al. 2001).

An important consideration in this respect is that of determining what kinds of organizational capabilities entrepreneurs require and what sorts of resources and competences they must acquire and/or develop to nurture them to adapt to competitive context. Addressing these issues, researchers appear to pay much attention to the *dynamicity* of capabilities and the *valuability* of resources and competencies. Dynamic capabilities (e.g., alliancing or partnering) mainly involve the reconfiguration of resources and competences to be able to act appropriately through value-creating processes in response to changing conditions, in conjunction with other capabilities, either to strengthen the *existing position* or to move to a *another* position (Iansiti and Clark 1994; Teece 1998; Fujimoto 1999; Cockburn et al. 2000; Karim and Mitchell 2000). This process constitutes some form of learning and is seen as critical to sustaining superior performance. Yet, notably, it is the *managerial cognition*, i.e., how they define the problem space and develop strategic prescriptions, which has a direct influence on such dynamicity (Prahalad and Hamel 1990; Eisenhardt and Martin 2000; Tripsas and Gavetti 2000; Jones 2001; Huygens et al. 2001). Resources may have different values in different situations, and they may change over time. The valuability is contingent on organizational conditions, their appropriability in respect of value-creating strategies to meet bargains from a host of stakeholders, and thus how they matter to the fruition of objectives and subsequent advantage in competition (see for instance, Collis and Montgomery

1995; Foss et al. 1995; Karim and Mitchell 2000). As causal ambiguity or social complexity may make it impossible for a firm to evaluate or even to identify the extent of value it individually creates (Barney 1991; Peteraf 1993), more formally, it is those bundles of resources and competences behind the success that are labeled as valuable once a firm is recognized as successful (Porter 1991); i.e., it involves an *ex-post quality perspective* (Foss et al. 1995).

This leads to the visualization of an important character of the impact of resources and competences on results, i.e., they provide competitive advantage through unique *synergies*. This implies that superior results, key to sustainable competitive advantage, cannot solely be attributed to a single resource or a competence but to the way they work together, improving the core capabilities of the organization in value-creating processes (Wernerfelt 1984; Prahalad and Hamel 1990; Peteraf 1993, Teece 1998, etc.). For instance:

> There is an issue of *complementarity*, i.e. the value of an individual resource is likely to be at least partially contingent upon the presence (or absence) of nother resources; that is, it may be a system of resources that matters, not the individual resources taken separately. (Foss et al. 1995, p. 8)

Collis and Montgomery (1995) note that, since all resources, competences, and capabilities depreciate, in order to maintain and build them, effective means are required for continual investment. Furthermore, the ability to change (or rather to act) can be limited by the inability to learn and to acquire and develop key resources and competences (Holbrook et al. 2000). Particularly when learning and change are not accommodated, organizations are challenged by absorptive capacity (see Cohen and Levinthal 1990), competency traps (see Levitt and March 1988), and core rigidities (see Leonard-Barton 1994).

4.5 Values that Are Instrumental to Deliver

Seeing some links between organizational attributes and performance, RBV theorists advocated that the profitability and growth of an organization should be understood in terms of the development and deployment of resources, competences, and capabilities. As the discussions and arguments continued, backed by more empirical verification of assertions, it became more acknowledged that their ownership enables an organization to perform better in order to achieve its intended results, that they are the primary sources of profit for the organization, that they are at the heart of an organization's competitive advantage, and that sustained competitivity lies in resource configurations, etc. (Rumelt 1987; Barney 1991; Grant 1991; Collis and Montgomery 1995; Teece et al. 1997; Bowman and Ambrosini 2000; Eisenhardt and Martin 2000).

Hence, notably, the significance of organizational resources, competences, and capabilities is substantial, and it can mainly be seen in relation to the large chunk of business activity aimed at producing a certain set of outputs that clearly matter for the very survival and prosperity of an organization (Winter 2000). However, underlining the term *invisible assets* (i.e., those properties of an organization that have the potential to produce profit but do not formally show up on the balance sheet), Itami and Roehl (1987) argue that those invisible assets are often overlooked, yet they are the most enduring sources for business advantage. Failure to recognize their *instrumental value* can be a cause of serious damage to an organization's competitive position (Cohen and Levinthal 1990; King and Zeithaml 2001), since obviously:

> In competitive environments, incompetent organizations are unlikely to survive for long. (Doz 1997, p. 58)

The underlying central message is that resources, competences, and capabilities contribute to organizational success (Prahalad and Hamel 1990; Snyder and Ebeling 1992; Mahoney and Pandian 1992; Montgomery 1995; Campbell and Goold 1997; Helfat 2000; Jones 2001) by being elements in value-creating strategies and thus in subsequent business activities (Porter 1996; Lei et al. 1996; Eisenhardt and Martin 2000), and by adding value through enabling organizations to exploit opportunities and/or neutralize threats (Penrose 1959; Porter 1980; Barney 1997; Teece 1998; Hitt et al. 2001). Hence, obviously from a sustainable business point of view, the acquisition and deployment of resources, competences, and capabilities are about harmonizing this value-delivery process (see also Prahalad and Hamel 1990; Grant 1996; Teece et al. 1997) with respect to the needs of stakeholders (Petts 1997). This implies that, if the commercial success of a business is contingent on profitability and growth achieved by delivering results *valued* by stakeholders (i.e., *terminal values*), then, as long as organizational resources, competences, and capabilities are key (i.e., *instrumental*) to driving this process, they can be considered as *instrumental business values*.

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Perspectives on Performance Assessment and Management

Jayantha P. Liyanage

1 Introduction

The emerging business environment can no longer be considered stable; it can best be characterized as complex, uncertain, and dynamic. Hence, scholars point out that those management approaches, which helped organizations to cope successfully with the steady, incremental change of the past, are outdated in respect of the scale and pace of the current change. In this environment, an organization's superior performance is no longer attributed not only to the possession of tangibles or financial resources, but also to the development and deployment of intangibles, particularly for competitive advantage. As intangibles gain a prominent share in the performance management process, traditional accounting-based performance measures are subjected to growing criticism, as they are seen to be retrospective, locked in time, lacking the requisite variety, and inadequate to give decision makers the range of information they need to manage business processes (Caves 1971; Chatterjee and Wernefelt 1991; Atkinson et al. 1997; Delios and Beamish 1999, etc.). The direct implication of this is simply dissatisfaction, as revealed for instance in the survey conducted by Cross and Lynch (1989). They reported that of 260 financial officers and 64 operating executives, 60 % were dissatisfied with their performance measurement system and 80 % thought their *control system* was not doing the job. Authors point out that this in turn stresses the need to re-evaluate and revamp longstanding performance measurement systems. Some of the prevailing dissatisfaction can also be attributed to the understanding that there are other forms of diverse forces, beyond the pure economic ones, that have gradually begun to gain momentum.

The current and the emerging global industrial order appears to be shaped by bundles of tangibles and intangibles, technological leadership, robust and flexible operating methods, long-term relationships, networking and partnerships, regulatory

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pressure, etc. In this business climate, organizations are compelled to do more than clarify business strategies to articulate and implement appropriate changes for ensuring sustained success (Arndt 1985; Cross and Lynch 1989). This implies that as Akehurst (1999) notes, profit is no longer considered the only variable that defines commercial success in the current business environment. What is instrumental in this regard can simply be visualized by reviewing successes and failures experienced by organizations to varying degrees under the current circumstances (Drucker 1998; Eccles 1998) and understanding what type of performance is considered rewarding. The latter is largely manifested in, for instance, the *Malcolm Baldrige National Quality Award*, the *European Quality Award*, and so on (see Neely et al. 1995; Garvin 1991; Eccles 1998). Furthermore, more popular scholarly work, for instance, within *stakeholder theory, resource-based theory, Balanced scorecard*, etc., have stimulated and contributed much to the underlying changes in perspectives on what matters for commercial success (also see Barney 1991; Kay 1993; Atkinson et al. 1997; Kaplan and Norton 2001, etc.).

In this challenging business climate, if improving performance is about making different decisions to change course without being solely retrospective, then performance assessment can be seen in a strategic planning context insofar as it thereby stimulates the necessary actions upfront that are deemed key to competitive advantage and commercial success. Furthermore, on the same tone, this has to be seen in relation to specific objectives that an organization or a process seeks to achieve (Neely et al. 1995; Kaplan and Norton 2001). This understanding calls for more than slight adjustments to traditional accounting-based measures, etc., and possibly, as Eccles (1998) advocates, requires starting from scratch to develop performance assessment systems that better foster necessary improvements toward long-term success. This further calls for a culture, in which shared understanding, effective communication, ownerships, goal-orientation, and so on are bundled together (Cross and Lynch 1989; Maskell 1989; Browne et al. 1997) to relieve some of the tensions created by inherent diversity and misconceptions within organizational settings.

More often, in the era in which tools and techniques for financial reporting are regarded the most sophisticated and remain the most deeply entrenched (Eccles 1998), the impact of some of the important processes on business performance is still mainly considered in relation to *costs* (Murray 1994). Such cost-based views on critical organizational processes have been greatly challenged and subjected to increasing criticisms lately. For instance, Drucker (1998) questions the underlying purpose of a business and insists that organizations are also paid to create wealth continuously and not solely to control costs to secure short-term profit margins. He notes that, unfortunately, this is not reflected in or captured by traditional measurement practices. Furthermore, Cross and Lynch (1989) and Skinner (1986) argue that an obsession with cost reduction produces narrowness of vision and an organizational backlash that works against its underlying purpose. The message is that there are forceful sources that call businesses to see beyond pure profits (i.e., mere *economic basis*) to incorporate other critical aspects (i.e., *institutional* or *social legitimacy* basis). In principle, those sources warn that not only profits but also the legitimacy of the process employed to earn profits are subjected to cautious review within the current sociopolitical and economic climate.

When ongoing debates are taken in context, the emerging business environment and changes within organizations create new risks and provide significant opportunities to revisit the course of a business. But this is contingent on our very ability, as Eccles (1998) notes, *to understand corporate grammar* and *redefine the vocabulary of the discipline*. Seemingly, there is already a strong safety and environment-related case for performance (see, for instance, Green 1994; Sweeney 1994; Shaw 1994, etc.), but in general it has to be seen in a more detailed business context. This not only calls for some form of a harmony with organizational objectives, for instance, as advocated by Cross (1988), Blanchard (1997), Akehurst (1999), Kutucuoglu, et al. (2001), Davies (2003), etc., but it also requires that the relevant subject matter should be explored in relation to what truly matters for the commercial success of a business.

2 Performance Management in Modern Context

The post-industrial era is known popularly as the age of information. As the transition toward a new regime of business continues, interests have been drawn toward *knowledge* and *intelligence* as strategic factors for competitive advantage (Porter 1985; Drucker 1993; Malhotra 1998). Interestingly, the *knowledge era* tends to establish processes based on *learning* and *knowledge*, where *intangibles* become critical factors for commercial success. In a way, managing performance in this environment can be seen as a cognitive activity: an activity involving interpreting, understanding, and making sense (McMaster 1995; Masoulas 1999), i.e., one that appeals to *intelligence*. It implies that *information, knowledge,* and *intelligence* are complimentary in driving the performance of organizational processes. Systematic management of business processes calls for effective assessments of performance, so that information generated can serve internal knowledge requirements and learning processes. This view recognizes an important association between *data* (i.e., raw facts), *performance indicators* (i.e., factual reflections of real-life behavior), *information* (i.e., facts with context and perspective), *knowledge* (insights drawn from information subjected to a learning process), and *intelligence* (i.e., reasoning and judgment of situations, or brainpower) (see Fig. 1).

Organizations and internal processes reside in a universe of data. In decision settings, two forms of data often count: firstly, those that relate to the performance of an organization or any of its processes (i.e., *performance-based*), and secondly those that relate to the environment, within which it exists (i.e., *peripheral*). The former is more often a basis for visualizing strengths and weaknesses, while the latter provides an understanding of opportunities and threats (see further Porter 1980). Any purposeful pursuit of specific data implies that the relevance and importance of those data are clear in the given context and that they can be put into certain decision perspectives. Along the same line of thought, indicators can be seen

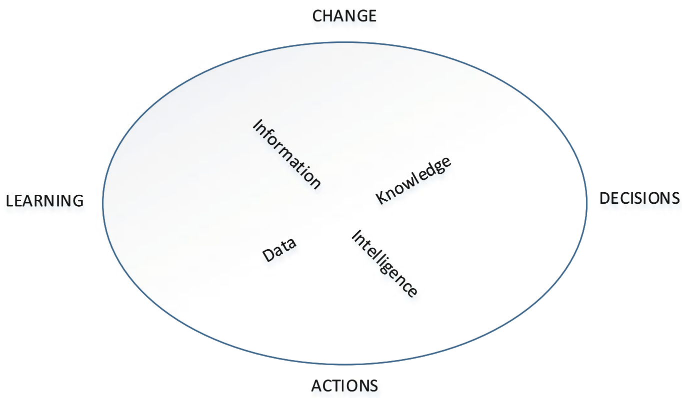

Fig. 1 Principal features of performance assessment in a modern context

as some form of factual reflections of real-life behavior or performance and that they are a critical part of the conversion process of data into sensible information. Such information is useful in many business process settings as they provide meaningful insight and understanding of a situation; i.e., they contribute to the existing body of knowledge about vivid aspects of performance. Such understanding offers organizations the capabilities to disseminate their knowledge in four major ways: *declarative* (what), *procedural* (how), *conditional* (when), and *axiomatic* (why) (see Bohn 1994; Nonaka 1994; Kotnour 1999; Antal 2000). However, knowledge at the process owner's disposal can hardly be considered perfect since there are large information asymmetries. Hence, such knowledge has twofold implications:

- Firstly, it guides our search process for more information seeking further clarification, and
- Secondly, it contributes to our reasoning and judgmental capabilities, i.e., *intelligence*.

Truly, the gap between knowledge and intelligence is fairly thin. Intelligence is also hard to define, and underlying descriptions generally constitute paradoxes (Quinn 1992; McGonagle and Vella 1993; McMaster 1995; Choo 1996; Nonaka et al. 1996; Davenport and Prusak 1998; Stewart 1998; Dulewicz 2000). Generally speaking, intelligence is seen in relation to the means of explanation (Khalfa 1994) or in relation to some forms of complicated thinking (Gregory 1994), leading to making choices. It is those choices, or in fact decisions, that lead to our actions; i.e., intelligence leads us forward through a judgment and reasoning process with various explanations. Contingent on knowledge, this incorporates diagnoses or prognoses to contribute to decision settings to shape and guide actions or behaviors. In fact, intelligence involves making sense of information. This is particularly so when information and knowledge asymmetries, and thus uncertainties or ambiguities, influence decision settings. Resulting actions can either be defensive or offensive in nature and may aim at some deliberate change. The term *change* as applied here may have wide implications, either internal or external, depending on the nature and impact of the dynamics.

Over the years, the discipline of performance management has attracted the increasing interest of many scholars owing to its significance in the modern economic climate (Allen 1988; Charles 1993; Vuorinen et al. 1998). Productivity and quality and their impact on business, in particular, appear to have largely been the more common focus for a long time and subsequently have drawn many interesting insights (see Gummesson 1993; Wilson 1988; Giarini 1991; Brignall and Ballantine 1996; Heskett et al. 1994). As global industrial conditions have begun to dramatically change the norms of competition, it is argued that modern competitive performance calls for: *concepts* (i.e., knowledge and ideas used to stimulate innovation and behavior), *competence* (i.e., high standards and quality to display high levels of professionalism), *connections* (i.e., collaborative and open structures based on networks and relationships which open up access to global resources), and so on, as important attributes of superior performance (see Kanter 1996; Thompson 1997, etc.) (see Fig. 2).

Regardless of the nature of change within the current economic, sociopolitical and technological climate, superior performance calls for, on the one hand, a clear vision of the accountabilities, drivers of results, etc., and, on the other, opportunities, threats, weaknesses, and strengths. Therefore, to stay on a competitive course, organizations need to develop smart and consistent techniques to explore internal and external settings (Porter 1980; Thompson 1997; Mintzberg et al. 1998, etc.). It is in this challenging environment that the management of business process performance also gains attention (see for instance, Sherman 1984; Armistead and Machin 1998; Looy et al. 1998; Vuorinen et al. 1998, etc.), particularly due to their sensitivity in coping with the dynamics of an emerging business context.

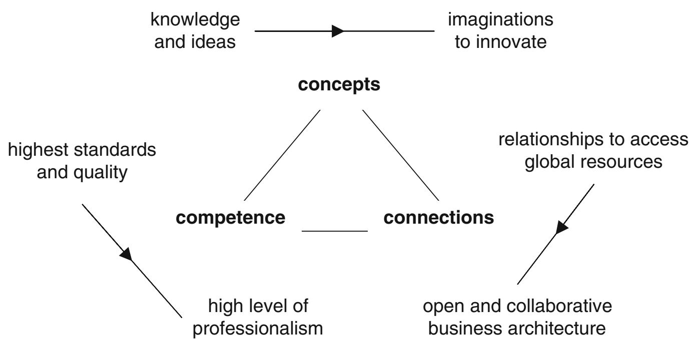

Fig. 2 Some of the principal issues for competitive performance in the modern economic climate (adapted from kanter 1996; Thompson 1997, etc.)

3 Indicators, Measures, and Measurement Systems

Notably, periodical assessment of performance has long being viewed as an important activity in management processes. The desire to introduce systematic performance assessment systems is not a whole new subject but goes back many decades (see Luck 1956; Hibi 1977, etc.). Today, this subject has received great momentum and is often coupled with stimulating discussions on economic value, productivity, total quality, safety, etc. The current enthusiasm has further been supported by modern views on the roles of tangibles and intangibles, as well as concepts such as *Balanced scorecard* that explored what truly complement financial results (Kaplan and Norton 1992).

During these developments, the usefulness of *performance indicators* became more evident in decision settings and has widely been acknowledged by the business community. In reality, says Sivalingam (1996), organizations which assume that they are doing fine, simply owing to the absence of complaints, are not performing to their full potential. They simply lack necessary standards at production facilities where no formal indicators are used to back such statements. Scholarly work on performance indicators has resulted in various illustrations, concepts, insights, methods, etc., quite diverse in the use of terms and definitions. The terms, indicators, indices, measures, parameters, and attributes, are often used interchangeably to explain assessment processes (see, for instance, Cater et al. 1992; Beebe 1994; Miller 1994; Murray 1994; Robinson 1994; Shaw 1994; Sweeney 1994; Neely et al. 1995; Browne et al. 1997; Pintelon and Puyvelde 1997; Visser 1998, etc.).

In principle, indicators provide some form of a signal (or an indication) of *performance* related to an aspect of reality or an area of interest (e.g., cost, occupational health, and employee competence). According to the Cambridge Dictionaries, *performance* is *how well they (a person or a machine) do a piece of work or an activity*. Also, Dwight (1999) defines it as the level to which the goal is attained. In essence, the definition of *performance* rests on two norms *expectations* (with respect to a goal, standard or to the question of *how well*) and *delivery* (with respect to attainment of a particular level, or doing the work or the activity). Presumably, performance by nature has a behavioral content. For instance, Cunningham (2002) defines it as *a series of behaviors designed to accomplish a goal or an objective*. The goal or the objective is in fact what we are bound or obliged to *deliver,* opting for a certain *process* (or a series of *behaviors*) that precedes. Hence, more broadly, we can define that:

> Performance is the extent to which expectations are delivered, after opting for a certain process.

Notably, it is not possible to measure performance by direct means all the time. It is for the same reason that Dwight (1994) insists on some innovation as long as those chosen means are deemed vital to the overall integrity of the assessment system. A *performance indicator system* hence can comprise both *quantitative* and *qualitative* indicators, as emphasized by Neely et al. (1995), and need to be derived consistently in accordance with a set of rules or guidelines specified by the performance assessment requirements of a business (also see Browne et al. 1997). In terms of decision settings, indicators in general can be used for both *prognosis* and *diagnosis*. The prognosis process involves some form of prediction of a likely situation or a condition, while diagnosis involves the identification of an exact existing situation or a condition. Both lead to some form of business decision. The context in which indicators are taken into actual use can better be illustrated with reference to Allender's (1997, p 23) analogy:

> 'The driver speeding along at 95mph slows down when he sees a police car in the distance. When we see that the temperature's going to drop to 5 deg, we will more than likely fetch our heavy coats from the closet to shield us from the cold. In business, the principle is the same: as before, a single number helps us comprehend the intensity of an operation. But when we extend this concept to the work environment, we give these measurements the sophisticated name of performance indicators.'

The emphasis here is that indicators eventually lead to some form of an action, and, moreover, such an action is triggered by a decision that in turn is contingent upon the judgment of a situation (see Fig. 3).

In this particular case, the action has no effect on the system from which the signal appears. But, in business settings, actions are directed at a target in the same system and, hence, assessments are meant to provide feedback about the quality or the impact (i.e., whether the action complies with requirements and introduces any other effects), the effectiveness (i.e., whether the situation concerned had been improved), and the efficiency (i.e., whether the improvement has come at an appreciable consumption of resources) of the action taken. Furthermore, the nature of judgments in real-life settings is that it is often subjective. However, in organizational settings, although the subjectivity can be more or less an inherent attribute in decision settings, the allowance of greater subjectivity can invite chaos. Particularly in business processes, where technical or operational decisions are largely involved, this subjectivity has to be reduced to a lesser degree for the purpose of consistency. It does not imply that creative or innovative solutions to a performance problem should be suppressed. The call from Armitage and Jardine

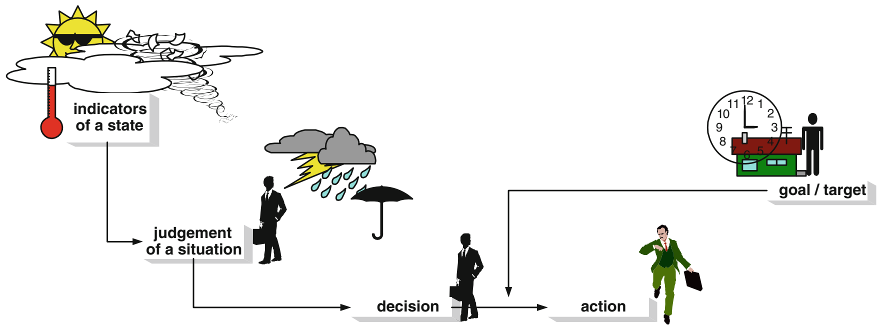

Fig. 3 Indicators are at the roots of actions

(1968) for *decision rules to act on* can also be seen in relation to this phenomenon. Such decision rules can be based on manufacturers' recommendations, standards or legal requirements, actual exposure, or prior knowledge of events.

Various issues related to the characteristics of suitable indicators (e.g., clarity, understandability, being well-defined, and reporting structure), critical success factors (e.g., creating a receptive environment, IT support), etc., have, to a great extent, been elaborated on by various scholars over the years (e.g., Cross and Lynch 1989; Ward 1991; Ptak 1994; Shaw 1994; De Groote 1995; Armitage 1996; Chapman et al. 1997; Paulsen et al. 1997; Neely et al. 1997; Ness and Cucuzza 1998; Tsang 1998b; Lam and Schaubroeck 1999). In general, the development of necessary indicators is not considered an easy task, and, as Dabbs (1982) and Pintelon and Puyvelde (1997) said, the biggest difficulty appears to be precisely defining and choosing indicators that are actually necessary and meaningful to a given setting. The message is that one may easily end up piling up far more than necessary indicators to a level, which is unmanageable.

> 'If one included a measure of every dimension of every sign or effect of a phenomenon, the number would be endless. There are more measures than phenomena, and one must carve out a domain of measures likely to be useful and to the point.' (Dabbs 1982, p 34)

As technologies become complex, societies become difficult to deal with, and competition becomes more dynamic, says Sweeney (1994); organizations are in need of new thinking on competitiveness and organizational effectiveness in order to broaden the factors that need to be considered and managed to produce competitiveness. Rhyne and Jones (1994) insist on the need for some criteria for the reassessment or review of existing performance assessment systems in parallel to business development and strategic planning.

> 'Designing a performance measurement system in a vacuum, i.e. uninformed by the strategic planning process, to evaluate the performance attributes of an operating system creates the possibility of disconnecting performance measurement from strategic planning, which is a common reason that performance measurement systems fail to meet expectations…to be effective, the system must mesh with strategic plans. The primary purpose of the strategic planning process is to clearly state the organization's objectives and its path to achieving them.' (Atkinson et al. 1997, pp. 26 and 36)

Any approach should provide an effective basis to visualize the business-related significance of any process, with respect to its overall effects, rather than purely assessing it in terms of costs (Luck 1956). This implies that, to be meaningful, performance has to be tailored to the mission and objectives set by process owners in respect of production systems and business requirements (Babington and Boggs 1991; Wisner and Fawcett 1991; McGonagle and Vella 1993; Sivalingam 1996). Accordingly, notes Dwight (1994), the performance assessment may have a varying degree of complexity, depending on how process owners seek to arrive at those objectives. In essence, this involves a combination of what are termed *outcome* (i.e., effects) and *process* (i.e., antecedents): a requisite for sustained standard, quality, and effectiveness of performance (see Early et al. 1990; Lam and Schaubroeck 1999). Thus, as Dwight (1995), Tsang (1998b), Visser (1998), Suwignjo et al.

(2000) note, the bulk of those indicators in use need to represent a hierarchy, depending on the assumptions implied in their use, and, more importantly, taking into account the nature and magnitude of impact on overall performance.

This issue further calls for some form of flexibility in the underlying performance assessment techniques to accommodate various strategic choices within organizational settings that take account of different changing circumstances. However, in general, the prevailing slow progress in this endeavor, as Green (1994) sees, can be attributed to the failure to grasp what truly constitutes productive performance owing to the inherent complexity of organizational phenomena. In essence, the underlying importance is on the degree of insight or the knowledge that those performance assessment systems collectively provide about performance, and thus on how effectively they unfold the inherent *complexity* and *casual ambiguity* of processes to the best possible extent.

4 Inherent Complexities and Ambiguities

The degree of *causal ambiguity* is defined by the complexity of the net of links that exist within a given business setting. The identification and specification of links or dependencies of processes are important to the extent that they provide an understanding of what issues actually affect important matters and an awareness of where to focus. Addressing this causal ambiguity calls for what is termed a *systems approach* that intends to visualize the *total being* (or the *holistic*, *generality*, or *interdisciplinary nature* as Von Bertalanffy (1968) calls it), rather than concentrating on *entities* that have some form of an independent existence. The word *system* is used in settings where there is a relatively complex assembly of elements (Von Bertalanffy 1968). Notably, organizational phenomena are inherently complex, and problems in such systems are mostly seen in relation to interrelationships. In a systems' view, performance has a certain structure that can be characterized as an ordered set of interconnections that provide an expression of the totality or an overall view (see also Green 1994; De Groote 1995; Visser 1998). The most important links of performance in this context are mainly threefold in nature, i.e., with the core business (*vertical*), with the other processes and to the external service markets (*lateral*), and of the events within the process itself (*self*). This can be termed as *concurrent performance thinking* (see Fig. 4).

Scholars (Heskett et al. 1994; Collier 1995; Gummesson 1993) cite that it is meaningless to express the importance of productivity or quality without any causal link with and within the business that it serves. This is also an issue constantly reiterated by many others on process performance (e.g., Babington and Boggs 1991; Ptak 1994; Rouse et al. 1997; Arts et al. 1998; Visser 1998; Tsang et al. 1999, etc.). Vertical integration, says Tsang (1998a), remains a requisite as there is an inherent need for every internal process to support the corporate mission and uphold the core values of the organization. And, moreover, as noted by Atkinson et al. (1997), such effective integrations remain one of the most difficult tasks of

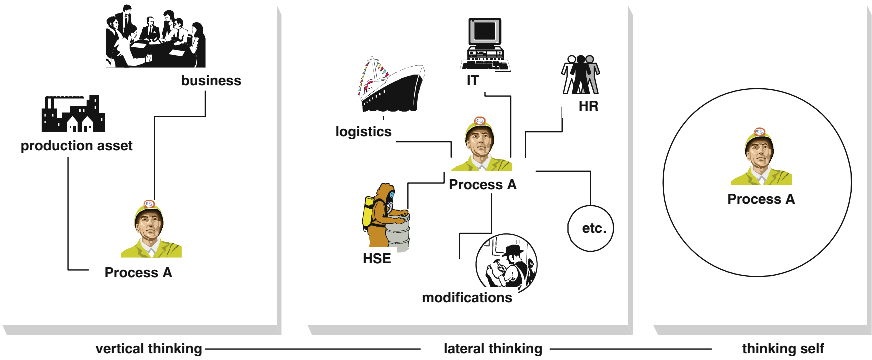

Fig. 4 Concurrent performance thinking. A basis to address complexity and causal ambiguity

businesses. From another perspective, it is equally important to take the necessary steps to avoid the internal conflicts and sub-optimizations that occur due to the presence of competing objectives, different priorities and preferences, etc. (Shapiro 1977; Fry and Cox 1989; Green 1994). This requires what is termed a *process focus* (see Ljunberg 1998) that allows an important view into the type and nature of exchange with other processes (Ptak 1994; Miyake et al. 1995). Since the very existence of such interdependencies can influence various areas of process performance, one has to fully understand the effects and to specify whether some *collaboration* is necessary (Pintelon and Wassenhove 1991; De Groote 1995; Arts et al. 1998). These can be seen as *complementary links* since process performance is not self-sufficient enough to deliver by itself the overall results expected. Thus, according to Chapman et al. (1997), management is already paying considerable attention to better visualize the levels of internal dependencies and their eventual impact on overall business performance. In essence:

> 'When evaluating the performance of a function that contributes to a larger organization, knowledge of that function's impact on the organization's value chain is fundamental.' (Porter 1985, p. 47)

Obviously, organizational phenomena are not only complex, but also dynamic, and changes take place as those organizations try to adapt to changing environments. On those grounds, performance assessment (and its management) becomes a dynamic process, note Suwignjo et al. (2000), and thus, consequently, performance indicators can be seen to vary between organizations as they resort to different directions. Indicators that are important today in a given setting can become less important tomorrow, and, furthermore, they may change over time. It is owing to this character, Sink (1991, p. 23) notes, that:

> 'Measurement is complex and still an unresolved mystery. Measurement is complex, frustrating, difficult, challenging, important, abused and misused…measurement at the individual, group, and organizational levels has tremendous problems, as well as opportunities associated with it.'

To overcome this stress, as Rhyne and Jones (1994) state, it is necessary to adapt performance to the changing environment and to refine the assessment system accordingly. This calls for adequate flexibility in models and assessment techniques. However, if it is necessary to redefine the role of process performance, particularly in business terms, and demonstrate its contribution as a value-added process (Trotter 1987; Murray 1994), then it calls for a new form of clues to get a deeper understanding of the phenomenon, and even of what organizational values truly are (Susman and Evered 1978). This also implies that the need to resolve the *mystery* is not in fact grounded within the indicators themselves but rather on clarity, consistency, and the flexibility of the approach chosen to formulate the basis for deriving those relevant indicators.

Owing to the fact that organizational systems are complex, there is a need to model such complex systems (Rubenstein and Firstnberg 1995), taking account of the integrative nature of events (Eccles 1998). Interestingly, Visser (1998) discusses *open and dynamic systems* (that are involved in some form of an exchange with the environment) that are mostly *non-deterministic* (due to the stochastic nature of events), as they involve a continuous *transformation* or a *conversion process* (that uses certain inputs and transforms these inputs into useful outputs). Help in managing such complex systems by the use of performance assessment systems first and foremost calls for some form of a framework that bears a combination of several different *perspectives*, which guide the selection and grouping of indicators, and also provides the basis for setting necessary performance standards (Trotter 1987; Dwight 1994; Ptak 1994). What is more, as Atkinson et al. (1997) point out, it also constitutes important choices made about the governance structure. With respect to current business settings, such a structure that bears a different perspective must be well balanced such that its business impact can be assessed with a larger scope than a single focus on financial performance alone (see Rhyne and Jones 1994; Rouse et al. 1997; and also Kaplan and Norton 2001). In essence, this importantly points to the need for enduring attempts to *dimension* performance, aiming to simplify its real-life *complexity*.

Continuous attempts to unwrap such complexity also target more comprehensive frameworks, for instance, as Roos and Øijord (1992) suggest, for understanding not only various dimensions of performance, but also the driving forces behind it, or, as Dwight (1994) insists, for determining the *levers* of improving performance. In this endeavor, a typical problem is identifying and integrating them systematically and logically from a very heterogeneous picture to a single model (Rangone 1996; Neely and Wilson 1992). Any attempt in this regard can be seen as a constructive cognitive exercise, incorporating both objective and subjective facts to model the reality, and is contingent on the width and the breadth of knowledge at one's disposal. On that ground, unfolding *casual ambiguity* has a strong epistemological basis.

Addressing this issue mainly involves systematic visualization of *effects* (and of course *causes* of them), insist Lam and Schaubroeck (1999), commencing from the very organizational requirements specified at the *top* that render the necessity for some form of a *logical hierarchy*. This firstly pays attention to *cascading*, i.e., using a *top-down* approach in the specification of a performance structure (see, for instance, discussions by Doumeingts et al. 1994; Carson and Leonard 1998; Tsang 1998a). Secondly, it also stresses a *bottom-up* component, i.e., to allow process owners to study how outputs are affected by changes in inputs or how results are achieved (Roos and Øijord 1992; Visser 1998). The interdisciplinary view of performance created by such a *logical causal structure* importantly allows *outcome measures* and *performance drivers* to be identified, contributing to the incorporation of non-economic factors for a fully functional approach, which satisfies the need to look at both tangible and intangible aspects of performance (Rhyne and Jones 1994; Rouse et al. 1997; Tsang 1998b; Lam and Schaubroeck 1999). Eventually, a sensitive approach comprises a *logically* derived relevant performance structure that can better express effects and their underlying causes, which in turn contribute to the continuous effort of unfolding *causal ambiguity* of O&M performance.

In essence, notes Visser (1998), performance modeling is of great importance to the process owners of any organizational system, owing to the need for reducing inherent challenges in decision settings. Hence, a model proves useful insofar as it provides insights to the required depth that management needs to make appropriate choices in the system, so that it not only constitutes *descriptive power* (i.e., enables assessing past performance), but also importantly bears some *predictive power* (i.e., shows something important is going out of control) and guides subsequent action before too much damage has been done (see Armitage and Jardine 1968; Neely et al. 1995; Atkinson et al. 1997). A critical characteristic of a model in this regard is its *completeness*, and that of a performance assessment system it accommodates is its *relevance* (Pintelon and Wassenhove 1991; Green 1994; Eccles 1998, etc.). Since organizational settings (i.e., conditions, priorities, and preferences) are distinct by nature, the issue of *relevance* in particular underlies the *specificity* of a situation. This implies that while a model can be made generic across all possible cases, the most effective performance assessment criteria that follow and the choice of indicators are solely at the discretion of process owners of those individual settings in order to ensure such relevance. Moreover, as Dwight (1994) says, the attributes of standards, controllability, perceived influence, etc., also equally contribute to this situation.

However, unfortunately, observes Visser (1998), even if there is an increased awareness of the importance of performance assessment in an industrial enterprise and even it is understood that process owners need comprehensive models to assist them in decision settings, this has not yet led to a more structured approach to resolving modern challenges associated with performance. Any attempt to address this issue requires a systematic and detailed exploration, with careful thoughts, useful and relevant information, and intellectual accounts, and equally importantly needs to incorporate innovation and creativity. Neely et al. (1995) underline some of the difficulties in this regard, for instance: integration of various aspects, conflict resolution with a view to different disciplines, generalizability across various settings, application of balanced scorecard in service settings, and flexibility with respect to changing circumstances (also see Rouse et al. 1997; Carson and Leonard 1998; Tsang et al. 1999, etc.). Such challenges call for a comprehensive exploration of the wilderness of performance to study the complexity and to comprehend the links. This is important as it provides a more holistic understanding of all important elements that constitute the whole (see Vuorinen et al. 1998), coupling tangibles and intangibles rather than visualizing bits and pieces that can potentially distort the global view of performance. Despite the fact that there is a considerable body of scholarly work on the subject matter of performance as well as on performance assessment and management in general, there is still a need for innovative and creative efforts to properly address the two issues, complexity and causal ambiguity, under modern dynamic settings.

5 Paving the Future Path

Many recommendations and methods proposed by various scholars often seem to have a common basis, i.e., the criticism that traditional techniques for assessing performance are not adequate with respect to today's circumstances. The main critique is often that classical assessment systems are subjected only to the needs of accounting. It is often cited that they are not being adequately related to expanding business requirements, they fail to measure all the factors that create value, their focus is short term at the expense of future growth, they suffer from lack of relevance, they are subjected to manipulations, they distort the understanding, they are descriptive rather than prescriptive, their information reporting is largely fragmented and often misleading, and they mostly encourage dysfunctional behavior, etc. (see Luck 1956; Armitage and Jardine 1968; Husband 1986; Trotter 1987; Cross and Lynch 1989; Roos and Øijord 1992; Shaw 1994; Sweeney 1994; Sivalingam 1996; Browne et al. 1997; Chapman et al. 1997; Rouse et al. 1997; Eccles 1998; Tsang 1998a; Mitchell 1999, etc.). As Eccles (1998) notes, such accounting-based measures and reporting assume that they reflect an organization's economic conditions more accurately, and that they are the very measures markets focus on and thus determine stock prices. As Drucker (1998) argues, it is those false assumptions that directly contribute to the growing criticism that those methods are simply not the right ones, and not because the technique is fundamentally wrong. In essence, they do not appear to adequately serve the bulk of informational and knowledge requirements in current business decision settings.

Nowadays, it is widely acknowledged that sensitive aspects that define an organization's economic condition and growth prospects are quite diverse. Accordingly, the focus has been enlarged to capture intangibles, stakeholders, non-financial aspects, etc. (Kaplan and Norton 1992; Cross and Lynch 1989; Edvinsson and Malone 1997; Sveiby 1997b; Drucker 1998; Eccles 1998; Lam and Schaubroeck 1999, etc.). The new trend looks into economic wealth rather than costs and profits (see Keen 1997; Ehrbar 1998; Young and O'Byrne 2001); it focuses not only on results, but also on the underlying process drivers (Wernerfelt 1984; Prahalad and Hamel 1990; Barney 1991; Kaplan and Norton 1992; Sveiby 1997a; Edvinsson and Malone 1997) and provides insight into new and important dimensions of performance (Pintelon and Wassenhove 1991; Sweeney 1994; De Groote 1995; Drucker 1998; Tsang 1998a). More importantly, this allows various professionals and organizations to visualize performance from different vantage points with respect to socio-economic, technical, environmental, aspects.

In fact, the continuous criticism on the inadequacy of historical methods can also be seen in relation to *evolution*. It implies that, with social growth, technological advancement, increasing economic uncertainties, visible changes in the eco system, and so on, *what actually fits in and what does not* in a business's path to prosperity may take notable turns. Firstly, such issues affect the *reality*, i.e., directly affect perceived accountabilities of businesses, competitive norms, drivers of commercial success, and thus the course of action. And secondly, they impact the *epistemology*, i.e., affects knowledge levels held by individuals and stimulates the search for novel, more innovative or, in the best case, groundbreaking frontiers to describe and prescribe performance. Thus, the plethora of historical performance assessment methods available at one's disposal should be viewed in this respect: that they are meant to satisfy the criteria that were deemed to represent at their best the main ingredients for success in the particular era. Such an era has gradually evolved from those periods that nurtured, for instance, Taylor's scientific management, through business process reengineering, just in time, lean manufacturing, etc., to total quality move, balanced scorecard, stakeholder orientation, resource-based theory of the firm, etc. The assertion here is that judgment on the adequacy and qualification of any method proposed or recommended is contingent on the extent to which it addresses information and knowledge requirements critical for the era in question. It is from this specific perspective that efforts need to be taken to resolve the modern and emerging performance challenges of industry.

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Integrated Performance Framework for Sustainable Manufacturing Networks

Jakob E. Beer and Jayantha P. Liyanage

1 Introduction

Many manufacturing industries have undergone substantial changes over the past decades, and organizations have gone through integration and disintegration efforts with mixed success. Performance management—as a means for turning strategy into operations (Sink 1993)—has followed organizational development to some extent. The scope of performance management has broadened to cover a wide body of performance levers that represent vital functions of the organization. In the course of this development, companies have learned to integrate seemingly independent corporate characteristics and brought them together through linkage of causes and effects as incorporated in the concepts the balanced scorecard (Kaplan and Norton 1996) and strategy maps (Kaplan and Norton 2004)—concepts that can be traced back to ideas proposed several decades ago and that have been 'reinvented' frequently (Neely 2005).

A dimension of performance which had not been part of most corporate performance frameworks but which has gained broad attention throughout the past 15 years is *sustainability*. Societal and environmental side effects of business have largely remained unattended throughout the corporate landscape, whereas meeting shareholder interests has tended to become the sole gauge of success—a development that has become subject of discussion among business ethics professionals and academics (Donaldson and Preston 1995; Freeman 2004; Heath 2006; Jones

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et al. 2007; Phillips et al. 2003). Increasingly often, however, companies release reports on their sustainability performance (Lydenberg et al. 2010) and there are ample frameworks and guidelines to choose from. The reasons for companies to report sustainability performance to public or to use it as information base for internal decision making are various, and so is the substance of the performance assessments and interest in sustainability. It ranges from 'greenwashing' (Cherry and Sneirson 2011; Ramus and Montiel 2005) to well-intended but weakly implemented approaches to genuine interest in improved sustainability and sound performance. This chapter introduces a framework for sustainability performance, the purpose of which is to clarify causes and effects of (un)sustainable business patterns and to outline ways for leverage. The framework is intended to take into account the complex interrelations with other actors in modern manufacturing environments, a weakness we identified in other frameworks. The necessity to take into account interrelations rests on the move toward manufacturing networks that can be observed in several industries such as electronics (Sturgeon 2002), automotive (Urban 2007), and agricultural machinery.

2 Move Toward Manufacturing Networks

A trend that can be observed in several industries is the development toward complex networks. Why and how networks form has been subject to intensive discussion in several domains of organizational theory, and reasons can be found (i.a.) in change of firm environment (Koka et al. 2006), product complexity, globalized customer base with a broad variety of additional requirements, opportunities for geographic arbitrage, requirements for certain skill sets and supply that cannot be met in-house, distribution and pooling of risk (Sturgeon 2002), incorporation of new technologies that traditionally have not been part of an industry (such as hybrid technology in automotive; Supplier Business Ltd. 2009), joint purchasing for increased negotiation power (Supplier Business Ltd. 2009), and joint logistics for decreased cost (Chopra and Meindl 2010, p. 413). Cooperation appears to be an embraced idea to deal with changed circumstances (Kuhn and Hellingrath 2002).

Provided an industry has undergone such a development toward increased network activity—that is, for instance, higher number of ties, increased number of strong ties relative to weak ties, and higher transaction volumes—the result of limiting assessment of sustainability performance to an individual organization will suffer from a lack of relevance and meaning. What can be said of the sustainability performance of firms with little or no in-house production capacity whatsoever? Such firms do not waste significant amounts of energy and water, they do not poison rivers or neighborhoods, and they do not employ underage workers. Without taking into account value creation on different stages of the supply network, little can be said about such a firm's performance. Now, 'taking into account' does not necessarily require a full-blown performance assessment of each and every company in the supply network. While this approach would certainly provide deep insights and highly relevant results, it is simply not feasible. It may not be necessary, either. Using the focal firm—the OEM in most cases—as a starting point, we claim reasonable results can be obtained if the chain of causes and effects that determines sustainability performance of the firm's direct and indirect influences is followed up to a point where the influence of the important network partners is involved.

3 Conception of the Framework Design

3.1 Structuring Causes and Effects

Performance frameworks such as Global Reporting Initiative (GRI), EFQM, and ISO 14031 make a clear distinction between performance outcomes and their underlying causes. Any (meaningful) performance assessment serves a defined purpose which can be reframed as answer to the question 'Why do we want to measure performance?' (Lebas 1995). The response then needs to be 'Because we want to know how to improve X!' If the performance assessment cannot provide guidance for improvement, there is a reason to assume the system is misdesigned and not properly thought through. ISO 14031 has one category of indicators labeled 'Operational Performance Indicators' (OPI) covering (in a wider sense) the effects, outcome, and consequences of an organization's actions, and it has one category of indicators labeled 'Management Performance Indicators' (MPI), describing actions and processes (i.e., the causes) leading to the results. By employing these two categories, ISO 14031 provides the means to explain certain performance outcomes with reference to underlying causes. The same applies to EFQM with its categories labeled 'enablers' and 'results' that serve the same purpose. In GRI, the categories are called 'Management Approach' and 'Performance Indicators,' respectively. Lebas (1995) has summarized the idea as follows:

> Understanding the processes underlying performance is the only way to define the measures that lead to actions. If we understand which of the steps in the process is defective, appropriate corrective action can be identified. If, however, only the final, most aggregated version of performance (…) is looked at, no appropriate corrective action can be identified. (Lebas 1995, p. 28)

Thus far, we have referred to a principle that is being considered and implemented in popular performance frameworks. Considering the development toward manufacturing networks outlined above, it appears following up causes for performance outcome on the organizational level may be insufficient in some cases. Taking into account network interdependencies, however, is not generally part of the common approaches to sustainability performance assessment, and there are some difficulties involved in trying to do so. If the performance impact of a network in which a firm participates is to be assessed, it is difficult to separate influence of the network from other possible causes. While it seems straightforward that firms *can* benefit from networks in a variety of ways (see, for instance, Uzzi 1997), one might encounter construct validity problems when trying to determine how exactly that would happen (Kenis and Oerlemans 2008). This problem is equally evident in quality management, and it is worth having a look at how it has been approached in this domain.

In the context of quality assurance in healthcare networks, Donabedian (1988, 2005) and Donabedian and Bashshur (2002) have proposed a framework that includes the structure of the organization, the internal processes, and the performance outcome. Including the structure of the organization in quality assessment is not so different from including a network structure in performance assessment as it is necessary to create a chain of causes and effects from the structure to the processes (as, for instance, reflected in the MPI of ISO 14031) to the performance outcome without being able to scientifically prove the proposed links in either case. In fact, this is what has been tried by Provan and Sydow (2008) for their assessment of *network effectiveness*. In their framework, *structure* refers to the types of links between organizations in a network (e.g., dyadic or multiplex, supplier relationship or alliance) and the general structural properties (density, fragmentation). These indicators can provide information about the stability of the network. Since the objective we are trying to achieve in this chapter is not to find evidence that network structure will have measurable performance impact but rather to avoid one major shortcoming of firm-centric sustainability performance assessment (i.e., low relevance of the result), we have to reflect first how the network actually is important as factor for sustainability performance.

3.2 Weaknesses of the Firm-Centric Perspective for Sustainability Assessment

In Sect. 2 of this chapter, we already pointed out that constraining sustainability performance assessment to an individual firm may well miss the mark and not offer any helpful insight or course for action at all. When value creation becomes more networked as it is, in fact, happening in several industries, then the assessment and removal of the negative by-products of value creation—that is, of any effects detrimental to sustainability—need to involve the network, too. In some industries, up to 70 % of value is created by suppliers before the OEM ever touches the product. In the car industry, this development is clearly visible in supplier parks where the amount, size, and complexity of components delivered to the OEM's final assembly are steadily increasing. In the agricultural industry, engines, cabins, tires, and most of the electronic components whose share in the final product is steadily increasing are produced by external suppliers. Although large production plants in these industries do consume considerable amounts of resources, the production process there does certainly not represent the major source of adverse environmental and societal impact. When more than merely incremental improvement is aimed for, important stakeholders need to be aligned to the same agenda.

An isolated firm-centric view does not only produce an inaccurate impression of sustainability performance but constrains a firm's opportunities to act upon its performance information. A change of the firm's business model, for instance, can significantly alter relations with suppliers and could be met with skepticism by banks, shareholders, and customers.

Furthermore, when options are reviewed to act upon performance data, individual firms may lack the foresight, the experience, and the resources and capabilities necessary to achieve lasting change when acting in isolation. Although hands-on experience in sustainability improvement is only scattered across the corporate landscape, having a capable and like-minded partner aboard is likely to improve the odds of success.

Last but not least, when sustainability performance assessments focus on one local entity, a lot of problems can simply be 'solved' by moving them outside the system boundary of the assessment. The problems will remain, of course, but they become invisible to the assessment. Employing workers for less than minimum wage? No problem—just contract them out to a dummy company. Using material that requires energy-intensive processes or whose extraction devastates the landscape? No problem, just purchase the material shelf-ready. Worried about underage workers doing 12 h shifts to assemble smartphones? Just contract manufacturing out to China and it will not spoil your corporate sustainability report. In short, local sustainability performance assessment cannot only be pointless as it does not include important information, and it can also create harmful incentives to obscure relevant information by moving the problems out of the local system boundaries and thus out of one's sight, thereby leaving the problems unaddressed.

3.3 Including Network Impact

We deem it sufficient to focus on the dyadic relationships of the firm that is subject to our assessment. We propose that much of the sustainability impact of the network can be captured this way. If we talk about a supplier or service company contracted by the focal firm, there are essentially three determinants of an effective, well-functioning relationship: (1) whether the supplier or service company *can* provide the right set of capabilities required to fulfill the job the focal firm wants them to fulfill; (2) whether the supplier or service company actually *wants* to fulfill the job to the full extent or whether it has diverging (or even conflicting) interests and objectives; and (3) whether there is a good level of trust, information exchange, and sympathy. We refer to these three conditions as (1) *capability matching*, (2) *objective alignment*, and (3) *partnership health*, respectively. An effective relationship to a supplier or service company becomes important if any action within the internal boundaries of the organization shall be taken which in effect will involve or require action (or approval) of entities outside the organizational boundaries—that is, if any supplier or service company is concerned.[1] In a complex network setting, this is a common case. Organizations do not exist in isolation and are not self-sufficient.

In the next paragraph, we are going to outline important elements of sustainability performance, many of which will directly or indirectly require a look beyond organizational boundaries.

3.4 Internal Performance Levers of Sustainability

Based on the literature review, examination of company exemplars, and with the help of creativity techniques, factors have been identified that influence sustainability performance of manufacturing networks. The factors have been limited to those that can be actively influenced; therefore, factors like environmental and social legislation which certainly do impact on sustainability performance, yet are beyond most individuals' and organizations' reach, have been excluded.

A common characteristic of these components—we label them *performance levers* to underline the importance and their functional logic in terms of sustainability performance—is that they cover broader than what Donabedian (1988, 2005), Donabedian and Bashshur (2002), and Provan and Sydow (2008) (see above) have described as processes. With one exception, the components identified are located internally but ultimately involve the network if they are to become effective. The five components we have identified as internal levers for sustainability performance are as follows: (1) strategy and business model, (2) product and service development, (3) performance management system, (4) governance, and (5) organizational culture. These five components represent categories within which a firm can 'pull the trigger' for significant improvements in sustainability performance provided its most important[2] network relationships will be supportive.

- *Strategy and Business Model* The strategy of a firm and its business model represent core levers for sustainability performance as they predetermine the limits within which a firm will be able to gain substantial improvements. There are business models that are inherently bound to inferior sustainability performance, and there are business models that can support firms in lowering damaging impact on society and environment.
- *Product and Service Development* In product and service development, firm policies and guidelines can have important implications as to the impact

[1]We do not address institutional performance impact (as, for instance, in private–public partnerships) in this chapter.

[2]The question remains which are 'the most important' network relationships. In this context, the most important relationships are the ones that by the nature of their operations have the highest impact on society and environment.

products and services will have on society and environment throughout their life cycle (Rebitzer 2002; Wimmer 1999).

- *Performance Management System* The firms' performance management system can create incentives for (un)sustainable behavior throughout all functional areas of the firm. There are plenty of examples of misleading incentives in the literature and practice. Things become even more complicated when individual financial rewards are tied to the performance management system (Neely et al. 2002).
- *Governance* The governance of the firm can influence how much capacity can be directed toward the achievement of sustainable business. There may be differences in whether a firm is largely family-owned and firm objectives are rooted in strong personal values and beliefs—or whether stock is publicly traded and investors aim at high short-term ROI.
- *Organizational Culture* The culture of the organization (Schein 1990, 2009) has influence on the diligence and motivation of each individual employee and may have decisive impact on firm objectives with respect to sustainability.

Of these five components, we believe that governance is the one least affected by network conditions. The links between internal performance levers and network conditions are not unidirectional, which may become most obvious when looking into organizational culture. Its organizational culture may influence the way a firm sees and approaches other firms in the network and thereby represents a major factor for how well the partnership health is going to be. In a similar context, Jones et al. (2007) propose that a firm's internal *stakeholder culture* will influence the priorities the firm assigns to its stakeholders (of which suppliers and service company represent a subset). Product and service development, too, will influence network conditions as it influences the objectives of the firm which then need to be aligned with network objectives.

It is important to point out that internal performance levers are not independent of each other. Part of the effectiveness of the performance management system, for instance, is dependent on a clear and complete strategy statement of the company from which performance objectives can be deduced.

3.5 Sustainability Performance Outcome

The last performance category we describe is the most obvious one. By the nature of their operations, firms have some impact on society and environment. This impact may be visible or not, and it may be quantifiable or not; diligent assessment of the firm's operations will, however, lead to some understanding as to what this impact might be. Fueled by warnings of climate change, CO_2 emission is one such outcome that gained attention in recent years, and firms throughout many industries have focused on CO_2 emission as an indicator for their sustainability performance. The World Business Council for Sustainable Development (WBCSD) proposes a

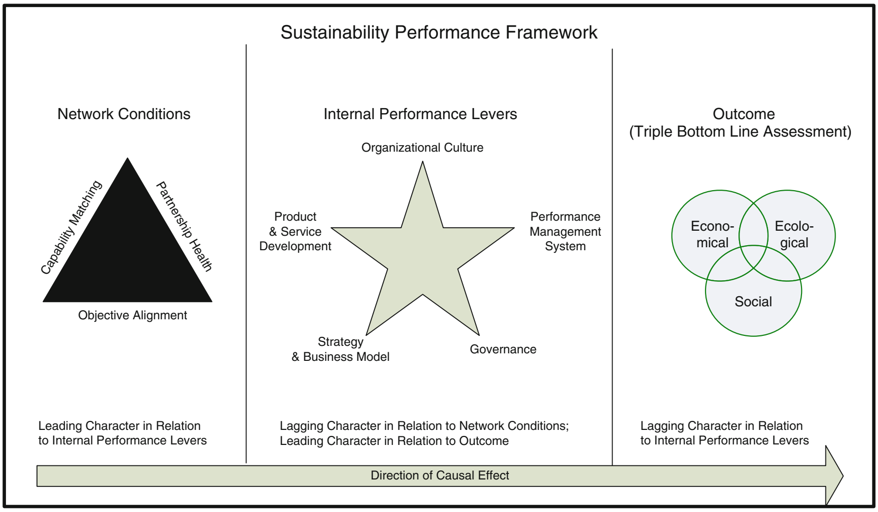

Fig. 1 Proposed sustainability performance framework

set of five areas of consumption and emission that can serve as example for the category sustainability performance outcome: energy consumption, materials consumption, water consumption, greenhouse gas emissions, and ozone depleting substance emissions (World Business Council for Sustainable Development (WBCSD) 2000). The five areas proposed by WBCSD represent physical consumption and emission that are, in theory at least, quantifiable. Referring to the quote from Lebas (1995) on p. 3, those indicators would not provide, however, information as to potential ways to improve, regardless of how exactly they can be quantified. Causes and effects leading to performance outcomes remain invisible if no further information about internal performance levers and network conditions is assessed.

After the principal components of the framework have been introduced and explained, we can present an illustration of the complete framework (Fig. 1).

4 Application of the Performance Framework

An organization's performance information can serve different purposes. For large, publicly traded corporations, it has become the rule rather than the exception to issue corporate sustainability reports. These reports' purpose is to inform stakeholders, such as shareholders, banks, communities, and customers about the actions the organization takes to be sustainable. Such reports are written for laymen, not for sustainability experts or management, so that the level of specific knowledge required to understand corporate sustainability reports tends to be low.

A different role is filled by performance reports that are not made public but intended to inform internal stakeholders who are supposed to act on the data. Different than public reports, information presented tends to be more fine-grained and requires a higher level of understanding. After all, internal reports are not a form of advertising as public corporate sustainability reports, in fact, often are. As these reports address mostly internal stakeholders, they can include confidential information which allows addressees to take specific action.

Both applications are legit and important. The different audiences require a different selection of data and way to present it. For each case, the understanding of causes and effects, as supported by the sustainability performance framework, is important. What are external stakeholders to learn from reading about CO_2 emission unless they understand why this year's level of emission represents serious progress as compared to last year's? By the same token, how shall decision makers know which lever to adjust unless they understand the (proposed) chain of cause and effect leading to the desired outcome?

The performance framework we presented here provides a handy and helpful illustration of important causal relationships, the understanding of which is key both to informed decisions (internal performance reports) and to any learning effect (external performance reports). The following two chapters of this book will provide more guidance as to possible applications of the framework and how it can be put in action. More specifically, the maturity assessment presented in the next chapter will demonstrate how an organization can adopt the framework and perform an assessment of its constituting elements before we will present tools to act on the performance information.

5 Conclusion

We have introduced a sustainability performance framework that attempts to integrate some conditions of the manufacturing network a company is embedded in (network conditions) with internal performance levers and tangible (measurable) performance outcomes. The rationale behind the integration is the development toward more densely connected manufacturing networks in several industries. With the higher degree of embeddedness in networks, the importance of the quality of the networks for companies' performance outcomes rises. We propose that companies can become limited in their options to achieve better sustainability performance when they encounter constraints in the network. Moreover, we contend that not all important performance values are tangible and easily measurable, so that suspected causal chains have to be identified and assessed.

We have identified three elements that we assert can have important implications for firm performance: capability matching, objective alignment, and partnership health. We propose these elements will influence a company in its abilities to make use of internal performance levers. As internal performance levers for sustainability performance, we identified strategy and business model, governance, performance management system, product and service development, and organizational culture. The influence of network conditions on internal performance levers differs in significance; governance, for instance, is less likely to be affected by network conditions than product and service development or strategy and business model. Nonetheless, it remains important to address all elements as each of them will eventually influence the performance outcome, as gauged by the triple-bottom-line assessment.

Performance management is iterative and enduring. Relying on measured performance values—reflecting past performance—is not sufficient to drive the firm toward future sustainable value creation. To make performance management successful, there has to be an ongoing discussion about the causes of performance outcomes and how the levers available can be utilized in order to achieve better outcomes.

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Maturity Assessment for Systematic Performance Improvement in Manufacturing Networks

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1 Introduction

The methodology for the maturity assessment for systematic performance improvement developed within SustainValue project (FP7-262931 SustainValue—http://www.sustainvalue.eu/) is presented in this chapter. This assessment addresses mainly sustainability performance at the network and firm level. The maturity assessment allows to analyze performances in the intangible elements and thus allows to explain the char-

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acteristics of the tangible measures (KPIs) of the Triple Bottom Line Assessment. For a vision on the possibilities of such integrated assessment, see Holgado et al. (2014).

According to the American Heritage Dictionary of the English Language, maturity is the state or quality of being fully grown or developed. The concept can be extended to encompass various stages in the growth, or development: therefore, and according to Paulk et al. (1993), process maturity is the extent to which a specific process is explicitly defined, managed, measured, controlled and effective. The idea of a staged measurement of maturity can be traced to the works of Deming (1986) and Juran (1988) on quality control.

Maturity models normally include a sequence of levels (or stages) that form an anticipated, desired, or logical path from an initial state to maturity (Röglinger et al. 2012). Indeed, it is possible to distinguish three main objectives of maturity models (Becker et al. 2009; de Bruin et al. 2005; Iversen et al. 1999; Maier et al. 2012): descriptive objective, prescriptive objective, and comparative objective.

A maturity framework was first developed by Crosby (1979), based on 5 evolutionary levels of adopting quality practices. This concept was further adapted by the Software Engineering Institute at the Carnegie Mellon University, in order to assess the capability of a software organization for developing and maintaining software products and processes (Paulk et al. 1993). According to this work, in a mature organization, processes are structured, consistent, accurately communicated to both existing staff and new employees; work activities are carried out according to the planned process. In such an organization, process and product quality are constantly reviewed and verified, and processes are updated when necessary. The outcome of Paulk et al. (1993) was a maturity model called Capability Maturity Model (CMM). Several capability maturity models were developed to assess maturity in software engineering, systems engineering, product and process development and many other disciplines. These models were later integrated by the CMMI Product Team (2001), giving birth to the Capability Maturity Model (Integrated). This approach is based on the idea that improvement is made by little steps, rather than by revolutionary changes, by focusing on some process areas and by adopting some key practices therein (Macchi et al. 2010; Macchi and Fumagalli 2013). CMMI and CMMI-like models identify several stages of development that can be applied to a whole organization (generating a staged representation of the system) or to the single process areas (the so-called continuous representation). In the first case, the model provides a predefined path for the company to improve its global maturity, while the continuous representation better fits the needs of a firm for selective process improvement, according to the firm's business objectives. CMMI-based models have been applied to several contexts, such as project management (Kwak and Ibbs 2002), reliability (Sander and Brombacher 2000), supply chain management (Handfield and Straight 2004), and construction industry (Sarshar et al. 2000).

The assessment, proposed herein, relies on consolidated approaches for maturity assessment, based on known maturity models. Maturity models (MMs) can be defined as staged roadmaps for assessing the capabilities of a company/organization with respect to a specific management domain (Becker et al. 2009).

There is a large variety of CMMI-based maturity models in literature, and each one is identified by a multiplicity of required characteristics in order to evaluate different organizational processes in different fields of application. In fact, for each application domain, there is the need to identify a model that can guarantee a standardized and objective evaluation process.

During a recent dissertation on this topic, Roy Wendler (2012) analyses 237 papers on the topic of maturity models primarily within the sector of software engineering, demonstrating an increase in scientific production on this topic. This generated the diffusion of the maturity model concept, but has not allowed to achieve a standardized approach and thus each model is somehow dedicated to a very narrow focus.

Within SustainValue project research, the aim has been to identify a standardized approach that can also support, together with the other tools developed within the project, an overall analysis. All in all, the maturity model that has been developed allowed to adopt a maturity assessment for intangible elements. This is a key issue that can be supported by maturity model. In fact, any time a best practice is not related with the achievement of a target indicator, but is related with the quality of the processes, maturity is under concern. Moreover, this approach to understand such intangible aspects allows to explain the characteristics of the tangible issues, such as key performance indicators measures.

In order to pursue this objective, the research has been base on the key requirements summarized by (Maier et al. 2012). This allowed to state the following requirements for the model:

- Simplicity: the model must be intuitive and easy to adopt in an operative way;
- Flexible: the model must adapt to different industrial context;
- Objective: the evaluation of maturity should not be biased by the interpretation of the analyst that adopts the maturity model and should be thus based on a structured process;
- Adaptive to a questionnaire: the model should be tailored in a way that a questionnaire can be adopted to implement the maturity assessment;
- Adaptive to the evaluation of process: the model must guarantee that the maturity is deployed along the common industrial process and thus a recognized classification of thus processes is used.

2 From Maturity Models to Maturity Assessment

According to the concept of maturity, previously introduced, the maturity assessment methodology herein proposed is based on the dynamic change of bringing a process in a status of full growth. This is a key vision to support the development of business processes (Maier et al. 2012).

To this end, starting from existing organizational configurations that describe the evolution of a company business, it is possible to decompose the life into discrete time period that can be interpreted as evolutionary stages (Scott 1999; Smith et al. 1985; Kazanjian and Drazin 1989; Kazanjian 1988; Gottschalk 2009). Finally, these stages are related to maturity levels and can be characterized by three key aspects (Gottschalk 2009): (i) they are by nature sequential states; (ii) they follow a hierarchic progression that can be hardly stopped, slowed down or inverted; (iii) the states are related with a large variety of processes, practices, etc.

It is also worth to mention why these sequential stages are followed. Moore and Tushman (1982), based on frameworks developed by Utterback and Abernathy (1975), consider evolutionary steps as consequence of growth of organizations and reaction to market stimulations.

Finally, it is possible to state that the maturity models represent the theory related with the ways of development of capabilities, competences, structures and organizational strategies (Gottschalk 2009; Kazanjian and Drazin 1989).

All in all, the identification of the role of maturity assessment models can be summarized by the work of Mettler (2011) that starts form the definition of two dimensions:

- The “what” dimension that consider at basis of the analysis some evolutionary stages that are encrypted in models;
- The “how” dimension that is the focus of methods that look at activities.

The role of maturity assessment model was well provided by Mettler (2011) that positions maturity assessment models between models and methods, highlighting the complexity of maturity assessment approaches.

García-Mireles et al. (2012) suggest that the application of MMs can be supported by tools such as questionnaires which can assist the evaluation of current status or improvement recommendations for an organization or a process.

This idea has been followed within SustainValue project in order to structure a tool that enables maturity assessment. Such tool consists of a questionnaire, based on the analysis of different Process Areas (PAs). The PAs are the “areas” of the governing framework at network and firm level.

The PAs are the following: objective alignment, capability matching, partnership health, organizational culture, strategy and business model, governance, performance management system, and product and service development.

The questionnaire has been thus developed by questions with closed answers: The questionnaire is a collection of questions concerned with different practices for each PAs, at different maturity levels. The questionnaire thus investigates such PAs and allows the selection of a series of characteristic attributes and the good/best practices in each PA, i.e., in each “area” within the governing framework, and definition of the maturity levels according to an ordered rank of practices (including best practices at the highest maturity levels). The attributes and the definition of maturity levels for each attribute were the basis for the development of a set of questions regarding each of the attributes which would evaluate the maturity level regarding each attribute for the assessment of each PA.

Closed answers are deployed for each question corresponding to the maturity levels/scores. Each answer has a score depending on the maturity level.

3 Process Areas to Address Network Conditions and Structural Elements

This section describes the maturity assessment for network conditions and structural elements developed within SustainValue project. Indeed, the identification of Process Areas is a key activity in order to deploy a good approach for maturity assessment. CMMI methodology, in fact, provides the basic elements to define the approach and set up the characteristics that the maturity model should follow, such as the number of levels and the rationale behind each level. Then, what links the maturity model with the domain specific aspects is the selection of the Process Areas.

In order to obtain a more structured maturity assessment approach, the Process Areas can be classified according to a certain hierarchy that allow a multilevel analysis that can be also useful, while applying the assessment, in order to make diagnosis on the critical point of the organization that undergoes the assessment.

Two aspects, as mentioned, have been identified as worth to be analyzed: network conditions, structural elements that define the following subsections. They provide an overview of the identified attributes and the developed questionnaire, focusing on the identified Process Areas, according to CMMI methodology.

3.1 Network Conditions

The attributes identified within the PAs at network level are summarized in Fig. 1 and are explained herein.

Objective Alignment This process area describes the match between an organization's individual objectives and interests with that of one or more of other partners within a manufacturing network. The attributes here identified are presented in Table 1.

Objective alignment	Capability matching	Partnership health
Sustainability objectives of contract partners	Assessment of contract partners' capabilities	Knowledge, information and data sharing
Criteria for sourcing and service contract decisions	Technological capability	Network level processes and division of work
Contract design & objective alignment	Resource availability and accessibility	Cost and benefit sharing
Life cycle thinking in contract design	Knowledge base	Decentralized – centralized decision making
	Collaboration capability	Relationship development

Fig. 1 Attributes identified within the PAs regarding network conditions

Table 1 Attributes related with the process area: objective alignment

Attribute	Description
Sustainability objectives of contract partners	It aims at identifying to what extent sustainability is part of the firm's contract partners' strategic objectives
Criteria for sourcing and service contract decisions	It is an attribute which reveals information about the partnership mindset of the focal firm. If sourcing and service contract decisions are solely made on the basis of economic efficiency, then contract partners may not be able to provide sustainable solutions that may potentially come with lower economic efficiency in the short term
Contract design and objective alignment	It concerns whether and to what extent objective alignment is part of the firm's contract design
Life cycle thinking in contract design	It aims to identify to what extent sustainability objectives have been "hard coded" in contracts with value-adding partner firms

Table 2 Attributes related with the process area: capability matching

Attribute	Description
Assessment of contract partners' capabilities	It considers the ability/competence of contract partners such as the suppliers, distributers, manufacturers, equipment providers to assist in decision-making. Companies may have varied methods for assessment
Technological capability	It involves evaluating and managing the investment and use of technologies and equipments for their social and environmental impacts. This could include evaluation and management procedures that companies may have to consider such impacts
Resource availability and accessibility	It refers to identifying, coordinating, and configuring physical, financial, and human resources across the industrial network to address resource requirements and capture
Knowledge base	It considers skills, experiences, and competencies in areas such as manufacturing processes and equipment use, while being aware of and recognizing sustainability issues (environmental, social, and economic)
Collaboration capability	It involves identifying, establishing, and improving interactions and relationships with multiple stakeholders across the industrial network to improve alliances for delivering sustainability

Capability Matching This process area describes the ability to deploy resources, skills, competences/abilities, and experiences of organizations for collaborative purpose. The corresponding attributes to this area are listed in Table 2.

Partnership Health This process area is an indicator of the condition or status of the mutual relationship between two or more partners within a manufacturing network. The attributes defined here are presented in Table 3.

Table 3 Attributes related with the process area: partnership health

Attribute	Description
Knowledge, information, and data sharing	It considers maturity of shared processes and integration related to data, information, or knowledge flows within network
Network level processes and division of work	It gathers the definition of contract partner's roles and responsibilities regarding to shared processes and development procedures
Cost and benefit sharing	It describes transparency of policies related to sharing of development costs and benefits
Decentralized–centralized decision-making	It portrays network structure and interaction between partners and their influence to network's joint decision-making procedures
Relationship development	It stands for contract partner's willingness and capabilities of codevelopment of relationship

Strategy and Business Model	Governance	Organizational Culture	Product and Service development	Performance Management System
Business strategy	Corporate governance	Empowerment of employees in improving sustainability	Solution demand analysis considering life cycle aspects	Consistency and strategic alignment of PMS
Design process for sustainable business modelling	Network governance & interdependence	Awareness of organizational culture	Product and Service Integrated solution offering	Performance objectives & indicators
Value network perspective	Sustainability commitment of owners		Exchange of information and knowledge	Use of PMS
TBL approach	Partnership portfolio management		Product-Service development process	Maintenance of PMS
			Sustainability-oriented techniques	Consideration of stakeholders in the PMS

Fig. 2 Attributes identified within the PAs regarding structural elements

3.2 *Structural Elements*

The structural elements concern the firm level, so these PAs are focused on the features of sustainability performance of the core company within a network. The five PAs, defined at firm level, cover the most significant internal factors impacting on sustainability performance. The attributes identified for these PAs are described herein and summarized in Fig. 2. After the description of each attribute, the questions within the questionnaire that belong to that attribute are introduced.

Table 4 Attributes related with the process area: organizational culture

Attribute	Description
Empowerment of employees in improving sustainability of the business	Since sustainable business behavior has to be “lived” by the firm’s employees in order to make a difference, this attribute considers how much individual employees of the firm are encouraged and empowered to pursue sustainability objectives
Awareness of organizational culture	It is no end in itself. This attribute assesses individual employees’ awareness of the firm’s organizational culture. If awareness is low, employees may not understand how the firm is driven by a potentially unsustainable culture and the firm is likely to be unable to change

Table 5 Attributes related with the process area: governance

Attribute	Description
Corporate governance	It describes sustainability integration to corporate governance procedures
Network governance and interdependence	It illustrates company’s ability to influence to other network actors and their sustainability objectives
Sustainability commitment of owners	It represents company owners’ interests related to long-term sustainability of company, its contract partners and broader its business ecosystem
Partnership portfolio management	It portrays maturity of company’s partnership and network management

Table 6 Attributes related with the process area: strategy and business model

Attribute	Description
Business strategy	It considers the integration of sustainability to drive initiatives and fully embed sustainability in the decisions and operations of the company
Design process for sustainable business modeling	It considers the delivery of sustainable value (environmental, social, and economic) by helping companies redesign and innovate their business model
Value network perspective	It involves a multistakeholder view for minimizing negative impacts (carbon emissions, waste, resource use, child labor), maximizing positive impacts (job creation, forging partnerships, market expansion) and value exchanges
Triple bottom line approach	It refers to integration of environmental, social, and economic sustainability into the business purpose and processes through initiatives and mechanisms in the area

Organizational Culture Organizational culture is often considered one of the main factors influencing organizational performance. This PA aims at studying how the organizational culture contributes to sustainability goals. The attributes identified in this area are listed in Table 4.

Governance Governance refers to mechanisms (for instance, processes, structures, norms) that organizations deploy to influence organization members and other stakeholders to contribute to organizational goals. The attributes defined here are listed in Table 5.

Table 7 Attributes related with the process area: product and service development

Attribute	Description
Product and Service integrated solution offer	It considers whether the offering of products and services is provided separately or integrated as a complete solution
Exchange of information and knowledge	It considers the information and knowledge flow among stages of the development process and how the supporting infrastructure is defined and updated
Solution demand analysis considering life cycle aspects	It concerns the procedure of analyzing the demand of solutions considering a life cycle perspective
Product–Service development process	It refers to the degree of definition and description of activities involved in the development process
Sustainability-oriented techniques	It considers whether techniques which have a concrete focus on sustainability aspects are used during the development process

Table 8 Attributes related with the process area: performance management system

Attribute	Description
Consistency and strategic alignment of performance management system	Generally, the performance management system is intended to operationalize strategy. This requires that the performance objectives are derived from strategy and performance management system supports the firm's strategic objectives. This attribute evaluates the match of performance management system with firm strategy
Performance objectives and indicators	This attributes aims at assessing design and content of performance indicators and performance reports
Use of performance management system	This attribute concerns how and to what extent the information management in the performance management system is used
Maintenance of performance management system	Strategy and objectives of a firm may change and performance management systems may need frequent adjustments to support the right objectives. The attribute considers whether and to what extent maintenance of the performance management system is conducted
Consideration of stakeholders in the performance management system	Since sustainable business needs to take into account a variety of stakeholders and because performance management systems by design are intended to "drive" a firm, it is crucial for sustainability purposes that stakeholder needs and expectations are part of the performance management system

Strategy and Business Model Strategy and business model are two interrelated concepts and they both have a high impact with the integration of sustainability in the core of a company. Some attributes were identified regarding these two concepts and are presented in Table 6.

Product and Service development This PA concerns the process of design and development related to products and services integrated in a complete solution to fulfill customer's needs. These initial phases in products and services' lives are crucial regarding their latter sustainability impacts, so sustainability aspects should be considered during the development process. The attributes identified here are listed in Table 7.

Performance management system The performance model management system of a company establishes an incentive scheme which may influence and have an impact on sustainability performance. The attributes presented in Table 8 were identified regarding this PA.

4 An Example of Use of the Proposed Approach

The maturity assessment could show a maturity profile regarding both network level and firm level. This maturity profile is based on the results of the questionnaire as the given answers are connected to the maturity levels of each attribute and the latter have a maturity score assigned according to the maturity level that they are connected to.

Summarizing the scores of all attributes within a PA, an integrated score for each PA would be obtained (from 1 to 5, corresponding with the five maturity levels). The scores regarding each PA could be visually illustrated in a spider chart for each of the areas or in an overall chart including the results of each area. It is suggested to use either one complete spider chart with all eight PAs at network and firm level or two spider charts separating PAs at network level and at firm level. Figure 3

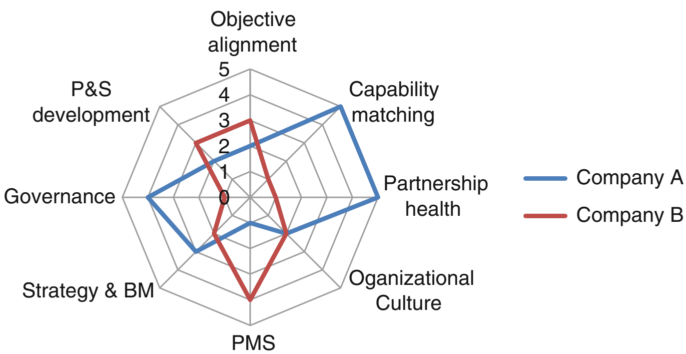

Fig. 3 Example of spider chart for maturity profile

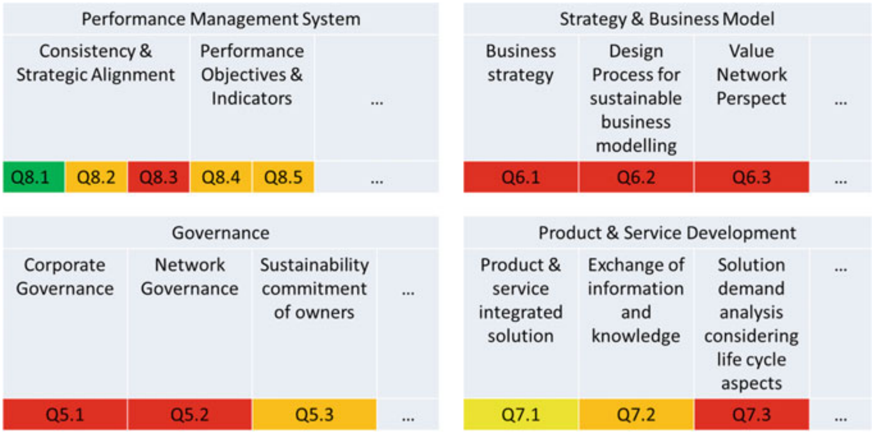

Fig. 4 Internal performance lever assessment of Company A

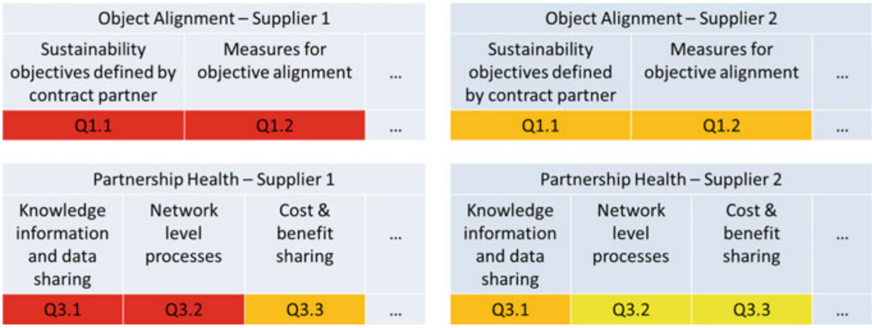

Fig. 5 Network conditions assessment of Company A

shows a proposal for a general view of the maturity assessment integrating all areas in a spider chart.

Hereafter, the example of application of the methodology to a company (called, for the example, Company A) is presented. Company A thus completed the questionnaire for maturity, and after the assessment, they visualized the results (Figs. 4 and 5).

While the company does have a supportive organizational culture with people who do care about sustainability, the assessment revealed that there are also some weak points in Company A's performance: The official strategy statement is virtually unknown to many members of Company A—which makes it difficult for employees to act and work toward achievement of this strategy. Then, despite its explicitly stated goal to become more sustainable, the company's annual report does not mention the term sustainability on any page, nor there is any kind of sustainable behavior supported by the company's performance management system. Consequently, employees are neither encouraged to improve sustainability nor are they punished if they move the opposite direction, despite genuine interest expressed by the company. Company A's product engineers have done a good job in creating durable and reliable machines, but they have not done yet anything beyond the *must goals* to ensure minimum negative impact on environment and society, such as use of material with low emissions related to its exploration and processing nor any other concept to reduce impact.

The results of its assessment were surprising for Company A for internal performance and were useful to understand network conditions with the assessment of partnership with suppliers. As the weaknesses of Company A have been identified, the company is now able to follow them up and to try to improve. Company A could learn from other companies that can apply the maturity assessment.

With help of the tools and methods provided, a company may thus identify suitable tools and methods that help it to progress and improve its practices, as seen in the example. For instance, within Company A, product development engineers may use checklists in the future in order to pay particular attention to product characteristics that improve product's sustainability over its life cycle. As a consequence of the maturity assessment results, Company A has decided to run a scenario analysis workshop with the management and the research institution it is connected to. To improve its performance management system, it will use the proposed characteristics of good performance indicators as proposed in this document. The example is a proof of the value of the proposed methodology.

5 The Role of Change Management for the Exploitation of Maturity Assessment

Future work may focus on the development of an automatic approach to evaluate maturity. One main issue of the proposed approach, in fact, is related with the analysis of the answers given to the questions reported in the supporting questionnaire. This could be automatized in order to allow a direct feedback to the companies that are using the proposed method. An example of this calculation of maturity is proposed by the wizard presented by Fumagalli and Negri (2014).

Moreover, it is not only worth to speed up the assessment process but also to support companies to drive the changes related with the improvement actions underlined by the results of the maturity assessment.

In order to outline the role of the change management that may follow the maturity assessment analysis, theories and approaches about the nature of change and change management processes must be introduced. By (2005) identifies three classifications of change that might be used in order to exploit the structured results provided by the maturity assessment:

(i) Change characterized by rate of occurrence (discontinuous, incremental, bumpy incremental, continuous, bumpy continuous change);
(ii) Change characterized by how it comes about (planned, emergent, by contingency, by choice);
(iii) Change characterized by scale (fine-tuning, incremental adjustment, modular transformation, corporate transformation).

The planned and incremental approaches should be followed. These approaches follow the principles postulated in the middle of the last century by Lindblom (1959) and Cyert and March (1956). They base their assumptions on the fact that each part of an entity (in our case a company) copes with a problem in an incremental and separate way, focusing on a single objective, one by one. In the long period, this may generate a radical change, well driven by planned and focused small changes in the short period. Moreover, a pillar of change management is the work of Kurt Lewin (Lewin 1946) that introduced the concept of *Planned Approach of Change* in the 1940s.

In order to further understand the concepts behind change management, it is useful mentioning Cameron and Green (2015) work that links Lewin's model with organizational metaphor of machine or organism. As an organism, the change comes from outside, while as machine the change derives from the plan of the management.

Indeed, Lewin pushes the importance of its theory, grounding on the capability to investigate the current state. Through the understanding of the actual situation, it is then possible to understand the behavior of the organization (Back 1992).

It is in that initial assessment of the actual state that the maturity assessment must be placed and may play an important role. This allows to see the maturity assessment results not as the ending point of the analysis, but as the starting point. The vision of processes and behaviors which are in equilibrium according to different forces is still valid. The processes and behaviors may be now substituted with the Process Areas, allowing a less generic approach, introducing within change management some engineering approaches. Since such approaches are targeting sustainability values and pushing the concept of collaboration, the overall change management that might follow will target as well such objectives and values.

6 Conclusions

The methodology for the maturity assessment for systematic performance improvement developed within SustainValue project has been presented within this chapter. The introduction of theoretical concepts related with maturity and the analysis of existing approaches and methodology for maturity assessment allowed to introduce an approach that can address analysis of intangible elements. Maturity models normally include a sequence of levels (or stages) that form an anticipated, desired, or logical path from an initial state of maturity to a more mature one. The methodology has been presented showing the different indicators that can be caught related with different Process Areas and attributes. A case supported the explanation and introduced the need of explaining how to cope with the following steps of analysis, namely how to trigger change management actions to deploy the suggestions provided by the maturity assessment. All in all, the chapter provided an overview of the maturity assessment approach that goes beyond the pure results of SustainValue project and provides to academic and industrial experts a guideline on how to approach the interesting topic of maturity analysis.

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