Eco-Efficiency in Industry and Science 27

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Editors

Environmental Management Accounting and Supply Chain Management

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ECO-EFFICIENCY IN INDUSTRY AND SCIENCE

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Environmental Management Accounting and Supply Chain Management

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Foreword

Sustainability requirements continue to be driven strongly both by regulators and customer demands. For some years, pressure concentrated on large, often stock-listed corporations. However, it soon became clear that much of the social and environmental impacts are to be found within the supply chain. As large multinationals hand down the societal pressure they are facing, suppliers increasingly need to be transparent about the social and ecological impacts of their products and services, and need to be able to assess and improve their respective performance. This creates new challenges. On the one hand, suppliers, often companies of much smaller scale and limited (financial and human) resources are faced with the need to deal with complex social and environmental issues. On the other hand, large companies with complex supply chains need to secure the consistency of data they receive by their suppliers, and need instruments for a meaningful interpretation of this data. To cope with this challenge in a consistent and cost effective manner, clear accounting standards and sound information systems are pivotal.

The literature on sustainable supply chains has reached a considerable level of maturity within the last years. However, accounting aspects have not been in the centre of attention of this discourse. The fifth volume in the Environmental and Sustainability Accounting Network (EMAN) research book series fills this gap by providing in-depth knowledge on supply chain related aspects of environmental management accounting. It offers both a general perspective on key issues and sector specific highlights for highly exposed industries like food and beverages (e.g. coffee, dairy), oil and gas and chemicals. A general perspective on environmental management accounting and on supply chain issues both upstream and downstream is rounded out by assessments of core regulatory developments, like the EU chemicals regulation REACH. Based on this comprehensive perspective, we believe this book to be of high value not only for academic readers, but also for interested practitioners.

Mr Michael Werner
Partner at Pricewaterhouse Coopers Germany and
Leader of the German PwC
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Preface

Recent developments in environmental and sustainability accounting are addressed in this fifth volume in the Environmental and Sustainability Management Accounting Network (EMAN) research book series. The main subject is the role of environmental management accounting in supply chain management – a topic which has been dealt with at various EMAN conferences from which a selection of the best papers is now collected. As well as highlighting new developments in environmental and sustainability management accounting (EMA) generally, the papers presented here link sustainable supply chain management with EMA, which was the core theme of the EMAN-EU conference held in Espoo, Finland, in 2007. The book also considered papers which originated from the EMAN-EU conferences on sustainability and corporate social responsibility accounting in Budapest in 2008 and on environmental accounting and sustainable development indicators in Prague in 2009, as well as the first EMAN Global Conference on integrated environmental management accounting for sustainable development at Tshwane, South Africa in 2008. It is a pleasure to see the number of participants at EMAN conferences continuing to flourish, with 150 attending in Espoo, 100 in Budapest, 200 in Prague and 120 in Tshwane. Given the changing core topics of the EMAN conferences, the conferences were attended by not only experts on EMA but also by academics and practitioners from different disciplines and industries. The continued interest in EMA is also reflected in the growing interest in EMAN generally and shows that the role of EMA is acknowledged in an increasing number of disciplines, professions and industries.

The result is that this volume is able to present a collection of contributions relating to sustainable supply chain management, the social and economic aspects of environmental and sustainability management accounting, and the integration of EMA with sustainable development, a characteristic of sustainability which is sadly lacking from much of the earlier literature.

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Part I
Introduction and Structure

Chapter 1
Sustainable Supply Chain Management and Environmental Management Accounting

Roger L. Burritt, Stefan Schaltegger, Martin Bennett, Tuula Pohjola, and Maria Csutora

Abstract Interests in and understanding of supply chain management are growing, along with a number of catalysts which include: reduction in trade barriers; development of logistics structures as a counterforce to globalisation; and reduced geographical spread in business. This raises a set of challenges for sustainable supply chain information management which is explored here, including: confidentiality and business records; cost-management and eco-efficiency; socio-cultural distance; complexity; and the need for rapid responses to the situation when a crisis occurs. These challenges lead to a critique of conventional cost management and the need to make sure credible information is provided in the supply chain relationship. A comprehensive Environmental Management Accounting (EMA) framework reveals that the links between sustainability management accounting and different decision settings are not clear in the supply chain relationship. The papers presented in this book provide a guide towards improved knowledge of EMA and supply chain accounting interrelationships, challenges and potential successes.

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1 Growing Importance of Supply Chain Management

Literature on sustainable supply chain management has increased substantially in volume over the last 15 years (Seuring and Muller 2008). Although the main focus of current supply chain literature, and of sustainable supply chain management literature in particular, is on other issues than information, the management of sustainability information has nevertheless attracted increasing attention.

This raises the questions of what has led to such an increase, and why sustainable supply chain management appears to be of growing importance to companies. Different possible reasons are examined here in turn: globalisation; cost-effective logistics processes; market-pull; information systems which shrink geographical proximity; and recognition of the interdependence between the dimensions of sustainability.

Supply chain management is closely connected to the issue of *globalisation* which is driven by reduced trade barriers, new logistic systems and lower transportation costs, as well as by new information technologies and the fast growth of newly developing and emerging markets.

First, trade barriers have been reduced by free trade agreements in particular through the World Trade Organisation (WTO), the European Union (EU internal market), the Asian Economic Society Association (ASEAN) and the North American Free Trade Association (NAFTA). This allows companies to produce and acquire goods and services in and from different countries in order to capture lower costs and efficiencies through operations or associations across state borders. These activities are primarily driven by the search for economic gain but can also have sustainability effects – for better or worse. If managed properly, globalisation can help to provide economic opportunities to poor countries and to improve the natural environment and the social quality of life across the world. If not, globalisation and its effects along the supply chain can cause substantial and long-lasting environmental, social and economic problems and even catastrophes, many of which might neither be intended nor immediately detected by either consumers or the companies which have entered into globalised trading. Which of these effects is created depends largely on the information available to managers, consumers and the media. The sustainability of globalisation depends on how it is designed, and this in turn depends on whether decision-makers have appropriate information and incentives and whether the effects of their decisions are transparent to society, regulators and consumers.

Second is the growth of new logistics structures, some of which can cause substantial environmental and social problems whilst others drive cleaner production and processes that are innately safe and secure, and are compliant with norms which respect fundamental human rights and environmental sustainability. The transportation of products, whether intermediate or final, was not an issue for most companies when production and sale took place locally as suppliers and purchasers were located in close proximity to each other. Global logistics management in contrast has developed to recognise all the activities associated with transactions, transformations and external events in the cross-border supply chain. These range from the purchase of raw materials in resource-rich countries to the production of goods in developing countries and the recycling of finished products, perhaps again in emerging or developing countries. Whether more regional production systems and clusters are preferred, or whether production is spread in tiny steps over the whole world, largely depends on the costs and reliability of transportation and logistics. In any case, the total transportation volume is increasing through not only globalisation but also the growth of economies in Asia, Latin America and Eastern Europe. EMA is therefore also challenged by different cultural contexts and the need to provide decision support to suppliers and investors in fast growing economies.

Third, as a reaction to various problematic effects of globalisation, many companies have experienced pressures from developed markets and their customers to manage their supply chains in the light of sustainability issues (known as 'market pull'). Customers increasingly require that sustainability is considered and that they can expect a supply of green and fair trade products. The challenge for companies is to keep track of environmental and social issues, not just the economic aspects of creating value, over the whole of their supply chains. This process is reinforced by media and journalists who observe and reveal production conditions along the supply chain, and various international standards such as ISO 14001 (environmental management systems), SA 8000 (social accountability) and ISO 26000 (social responsibility), which can be applied at every step of the supply chain.

Fourth is a shrinkage in geographical proximity, facilitated by cost-efficient communications mechanisms which speed the flow of information that parallels the transfer of production materials and products (both intermediate and final) between different parties in different countries, as well as assisting interested parties to track companies' actions in a fast and responsive manner. Given a combination of stakeholder pressure, market opportunities, and increasing opportunities relating to new information technologies, companies have started to establish detailed tracking and supply chain information systems which can be accessed even by customers and suppliers. These information systems mostly represent specific forms of Physical Environmental Management Accounting, but to ensure that the development of such progressive approaches contributes to increasing competitiveness they also should be linked to Monetary Environmental Management Accounting.

Because the emphasis is on *sustainable* supply chains, successful management requires not only high quality environmental, social and economic performance, but also their integration (Boyd et al. 2007). The interrelation and trade-off between dimensions of sustainability is a vitally important part of sustainable supply chain management, since sacrifices in one dimension can lead to disproportionate gains in other dimensions throughout the supply chain. Once recognised, these net gains in the chain can of course be shared between the parties (Shank and Govindarajan 1992). However, at this stage of development in understanding there is 'a clear deficit' (Seuring and Muller 2008:1702) in supply chain management literature about social and integration issues, with the main emphasis being on the economic and environmental dimensions (Linton et al. 2007).

Given these four core drivers of sustainable supply chain management, a closer examination of the reasons that managers engage in the topic may be helpful in order to understand the managerial requirements for EMA to support sustainable supply chain management. Seuring and Muller (2007:1703), based on available literature between 1994 and 2007, summarise six *external* incentives for including sustainability in supply chain management:

- Legal requirements and command-and-control regulations are the most frequently cited triggers for action, making regulators a primary stakeholder in sustainable supply chain management.
- Customer demands on the focal company are the second most highly ranked pressure.
- Responding to stakeholders comes a close third.
- Competitive advantage is important, and placed well ahead of pressure from social and environmental groups and reputation loss.
- In addition, internal risk management and the need for minimisation are seen to be important triggers for sustainable supply chain management. Seuring and Muller (2007:1704) suggest that risks can derive from potentially poor environmental or social performance, as well as from potential disruptions of supply.
- Increased outsourcing, particularly to overseas suppliers, multiplies the number of companies in different contexts in the typical supply chain, and thereby encourages the focal company to push their suppliers for an increase in take-up of and compliance with standards and codes of environmental management and social responsibility, so that performance can be improved.

In summary, sustainable supply chain management is increasing in importance to companies for a number of reasons related to external and internal risk, increases in globalised trade and reduction in the barriers to transportation and communications across borders. Taken together within a globalised setting, these manufacturing and information flow processes and product perspectives mean that supply chain management brings pressures to hold companies responsible for their environmental, social and economic performance, not just in their own premises but along the whole supply chain and in the light of expectations from customers, regulators and the media. In such a setting, whether concern is with the overall sustainable performance of the focal business, or with a part of the supply chain which is not under its direct control such as (say) product design and development, purchasing, or logistics, guilt by association with unacceptable practices of suppliers is an ever-present possibility (Seuring and Muller 2008). Hence, reputation-conscious companies tend to assume responsibility for bringing pressure on their suppliers to resist unsustainable practices. Focal companies in supply chains need to accept responsibility for helping to overcome any environmental or social problems associated with all the other companies in the chain. They are aware that any single part of the chain can bring down the other parts if unacceptable environmental or social impacts relating to production processes or lack of product sustainability catch the public eye. If aspersions are cast about the credibility of a supplier in the chain, the focal company's reputation can falter and collapse. Companies in supply chains in a globalised setting are subject to increased risks, requiring that management strategy is adapted in order to safeguard against high-risk outcomes.

2 Challenges of Sustainable Supply Chain Information Management

Given the growth in demand for sustainable supply chain management, what are the information challenges facing those companies which are keen to implement relevant management systems? How should environmental and sustainability management accounting be designed to provide the foundation for the supply chain and the sustainability information management challenges for internal management decision-making, as well as for internal and external reporting?

Five central challenges are mentioned in the literature: confidentiality and business secrets; movement from cost management to eco-efficiency; distance; complexity; societal observation and going global.

- *Confidentiality and business secrets*: Pereira (2009:372) argues that information management is the current supply chain frontier because although it provides a conduit for information transfer, the technology which it involves can introduce new risks to confidentiality, integrity and availability in the supply chain. A balance between the potential benefits and costs, and a consideration of the distribution of the benefits and costs of higher transparency between different parties in the supply chain, are essential if high-quality data are to be obtained from all these parties in order, say, to assess the environmental and social impacts of a product which has materials provided by countries with high levels of corruption. In this type of setting, environmental management and sustainability information management assume a premium place in order to provide support for sustainable decision-making based on credible environmental, economic and social data from suppliers.
- *Cost-management to eco-efficiency*: accounting for costs along the supply chain can help to reveal potential cost reduction through more efficient designs, or production or logistical organisation between partners. With accounting for eco-efficiency (Schaltegger 1998), EMA provides methods which can support this goal of supply chain management. However, to identify this potential requires a reliable and largely open communication of cost structures and thus also profit margins. This may not always be in the interest of all suppliers and can create tensions in business-to-business relationships.
- *Distance*: distance can be created not only by geography but also by cultural, social and economic differences, and these constitute a challenge to EMA for supply chain management. Prior to the growth of extended supply chains throughout the world, information about activities in the supply chain was easier to obtain

as local laws and customs, local cultures and local mores provided a common foundation. Of course, cultures differ between countries which means that countries can vary in the extent to which the rule of law appears to apply. In some countries corruption is the norm in relation to supplies and related information flows, e.g. where a government inspector will expect to receive a bribe for providing the desired information to enable their 'client' to demonstrate compliance with regulatory requirements (Spector 2005). In other countries the situation is less clear as in the recent case of Stern Hu, formerly of Rio Tinto, a large multinational mining business. Hu admitted to bribery in China, where corruption is a common part of everyday business activity (Garnaut and Liu 2010), and received a ten year sentence for undertaking activities which others see as being the norm.

- *Complexity*: with increasing outsourcing of production, supply chains spread over the world, and constant changes in suppliers and sub-contractors, an increase in complexity needs to be managed. With increasing sub-division of supply chains and the need for information confidentiality beginning to change, information-gathering settings and reliability have taken on renewed importance. Advanced information systems developments offset this complexity to an extent (Kaipia 2009:144). Nevertheless, when supply chain management is considered in its sustainability context, information flows take on an importance which has hitherto been underappreciated.
- *Societal observation and going global*: a final challenge is presented by the need for rapid responses to actions which are considered unacceptable. As supply chains in many industries have been extended to different countries, the growth of social networking tools has led to faster possibilities for non-governmental organisations to identify social and environmental problems and to spread information via media such as Facebook and Twitter, thus increasing the economic risk associated with the supply chain since a single bad incident can be sufficient to destroy brand value and ruin a company's reputation (e.g. currently BP in the Gulf of Mexico). In these circumstances successful brand management becomes crucial, and in order to differentiate a company through the sustainability of its products, its managers need good-quality information about the full extended supply chain. Demonstrating to social observers and watchdog groups that the information communicated is reliable requires standards and third party verification in order to create credibility for the information systems and the managers themselves.

To respond to these challenges, companies need new information systems about environmental and social impacts along the supply chain. Hence, data collection by very different companies in different cultural settings presents a problem for securing reliability in relation to decisions, as factors relating to the credibility of information are less controllable once the supplier is located in a different legal organisation, country, or cultural context.

Other challenges of supply chain information management include the coordination of actors so that they provide and pass on information; auditing and assurance; trust-building; and an understanding of why social and environmental issues are important to the focal company, all in a dynamic setting of constantly changing actors in the whole supply chain as subcontractors change.

3 Possible Approaches to Gathering Credible Sustainable Supply Chain Management Data

Credibility of sustainable supply chain data forms the fundamental foundation between parties that might be tempted to take short cuts and not engage in sustainable behaviours. If data transferred is unreliable, or if negative information is not forthcoming, then relationships can be soured and the brand image of the focal company severely affected or destroyed. Approaches to data gathering and transfer range from the mere presence of unspoken dormant power where a supplier would not risk a cover-up because of the consequences, to the actual exercise of power, to an agreement that common processes be introduced to assist with the voluntarily guided provision of self-reported information, or to the foundation of an organisation with the purpose of providing supply chain information and conducting supplier audits for all its members such as the Business Social Compliance Initiative (BSCI – http://www.bsci-eu.org/). The BSCI is a non-profit association founded by large retailers to audit supply chains and to provide information to the retailers to make sure that they do not ‘fall into a trap’ with non-compliant suppliers. The Initiative provides companies with a comprehensive monitoring and qualification system which covers all products sourced from any country and is open to all retail, brand and importation companies which are dedicated to the improvement of working conditions in their supply chain worldwide. This means that there is a variety of ways in which the relationship between supplier and supplied can be managed, where the cost of establishing and maintaining relationships increases as the use of power to extract information in an asymmetric situation increases. At one extreme the focal company can define data collection mechanisms whose substance and form are pre-specified. At the other extreme it can trust its supplier to provide data in a regular, reliable and credible manner. In between is a series of activities that can help to maintain trust between the supplier and purchaser such as: auditing in line with expectations; auditing in comparison with established standards such as ISO 14001, SA 8000 and ISO 26000; technical and ethical education; and training by the focal company of the supplier company’s managers and employees. Hence, one way in which trust between the parties can be bolstered is for an internal or external audit process to be part of contractual arrangements. This can ascertain whether data provided between the parties is what it is represented to be – accurate, and of sufficiently high quality to be relied upon in joint decision-making. A second way to build trust is for parties to build and hold a common ethical or philosophical understanding about the importance of environmental and social integrity of operations in the supply chain.

In each of these settings, consideration has to be given to the action which should be taken if a party fails to meet expectations. First, if considered to be of sufficient importance to economic and sustainable development, governments could introduce legislation to structure the relationships between parties in sustainable supply chain relationships similar to the rules that exist about financial information flows for companies which raise equity capital from the public, with an appropriate set of legislated penalties being devised. Second, in common law countries acceptable provisions for contracting and breach of contract in relation to sustainability issues can be established through decisions of the courts, with penalties for breach of contract being available. Where common law does not form the foundation for market transactions, e.g. in countries with religious foundations to their laws, this raises the issue of how to manage sustainable supply chain activities and associated cultural issues. A pragmatic perspective would suggest that an arrangement between supplier and supplied which is based on the rule of law is likely to be less efficient than a situation in which trust has been established, especially given differences in national regulations and the extent to which they are implemented and complied with. A workable approach is for the parties to build up trust between them that the supplier will provide data that is accurate and can be relied upon for assessing the performance of parties in the supply chain. As time passes, such trust can flourish, although it does not take much for low-trust relationships to emerge and to spiral out of control if suspicions arise about unacceptable behaviour (Fox 1974).

Whether based on fiat or trust, new voluntary initiatives are increasing the demand for EMA data to be gathered, classified, recorded and exchanged, so that suppliers can show their sustainability credentials in order to maintain and build their businesses. Supply chain management by large companies such as IBM, Otto Group and Wal-Mart typifies the current stimulus towards the development of EMA. Supply chain management and the requisite data flows reveal the complexities associated with managing organisations towards sustainability (Schaltegger and Burritt 2000).

In summary, Seuring and Muller (2008) emphasise the pressures that a focal company in a supply chain can bring to bear on its suppliers in relation to the provision of reliable data about environmental and social issues. The focal company can dominate the suppliers, or alternatively, it can work to build up a trusting relationship. It has the power to make suppliers provide credible data or else lose their supply contracts, although the presence of power does not necessarily mean that it actually has to be used. Given a singular lack of government involvement in sustainable supply chain relationships in practice, a focal company can dictate that a specific method of measurement and reporting must be used by its suppliers, and then by their suppliers further upstream, etc. Suppliers can be required to provide information on their sustainability which is subject to direct oversight and audit (or assurance) as it is obtained by employees of the focal company. For such a purpose, the requirements could be (1) those pre-specified by the focal company, based on its own standards; or (2) based on well-accepted voluntary standards such as ISO 14001 for environmental management issues or SA 8000 and ISO 26000 for social matters; or (3) standards based on global best practice as a benchmark for information quality. At the other extreme is the development of trust, leading suppliers to be intrinsically motivated to do what it is right to do and to provide accurate, reliable and useful information, and thereby to reduce the cost of strategic management control.

4 Potential Tensions and a Definition

Several aspects of the relationship between EMA and supply chain management can be distinguished.

First, since a supply chain involves cooperation between suppliers and purchasers, questions arise about what is internal to the organisation and what is external. Although the notion of the organisation as a separate legal entity is retained, the exact scope becomes fuzzy, with relationships between upstream suppliers, the organisation and downstream purchasers being viewed in a cooperative rather than legalistic manner. 'Partnerships across multiple companies' is a phrase which is commonly used. Although contractual links for the continuity of business provide the ultimate incentive for suppliers to comply with the demands of their purchaser, the need for close interaction between people from the different businesses in order to establish data-gathering systems blurs the organisational boundaries and raises issues of confidentiality and data security. EMA stretches across legal corporate boundaries. As a learning process, any application of EMA, and the design of EMA systems to support sustainable supply chain management, requires prior communication between partners along the supply chain to agree on the goals of the information system, its benefits, and the sharing of benefits and costs.

Second, relationships between parties involved in supply chain activities and arrangements need to be identified and managed in a positive and cooperative manner if the greatest efficiencies are to be gained for the reduced use of environmental resources, and the increased profitability of investments in processes to reduce resource use. Cooperation rather than conflict should be the driving force, which is consistent with pragmatic frameworks concerned to highlight the importance of networking in complex supply chain settings where integration of organisational relationships is the norm (Mentzner et al. 2001:4). EMA thus has to be viewed in its role as a supporting tool to strengthen partnerships as a collaborative network in competition with other supply chains or value added networks.

Third, the question arises as to how the net gains or losses from supply chain arrangements are to be distributed between the participants, both external and internal. The issue is one of equity and distribution between participants involved with or affected by the organisation. Shank and Govindarajan (1992) were one of the first to document the strategic importance of the equitable distribution of benefits from investments which affect all parties in the supply chain. They analysed an investment in a new logging technology (a switch to harvester/forwarders from buncher/skidders) to reveal that while the gains accruing directly to the logger were negligible, the downstream processing mills could make significant monetary gains, as could the upstream land owner, if the investment took place. Hence, it is critical for the logger to make the investment if all are to benefit. They thus demonstrate that unless data are available to all parties in the supply chain about the net benefits of a potential investment, the notion of somehow sharing the gain will not emerge in a systematic way and all parties will lose as a result. Strategic cost management was suggested as the way to get parties to recognise that sharing the net gains from investment by the loggers would be of benefit to all parties. Clearly some form of negotiation between the parties in the supply chain is needed and strategic cost management, as a particular EMA approach, is seen as being necessary for awareness of the potential lost opportunity to be raised. Furthermore, the costs of supply chain EMA, i.e. of collecting and managing supply chain information, can be reduced through a joint organisation which deals with information collection, quality assurance and sustainability audits for its members. Such an organisation can also contribute to a standardisation of information collection and provide comparability.

Fourth, industry structure is likely to influence the role for information gathering and use in supply chain settings. Vertically integrated organisations will tend to gather data internally and the points at which suppliers enter into daily activities will be reduced, thereby removing the impetus for supply chain management since internal movements and transactions will be the norm, perhaps with well-established transfer pricing rules being established. In contrast, where horizontal integration is the norm as with Wal-Mart, different functions in the supply chain will be provided by different organisations, and data-gathering and the use of supply chain management will have relatively greater importance as transactions take place in the market, rather than inside the company. One solution for less vertically integrated businesses is to create a joint organisation which collects the necessary information and conducts sustainability audits (such as, e.g. the Business Social Compliance Initiative).

Fifth, concern over EMA for supply chain management also raises the issue of efficiency improvements generated by cost savings and revenue enhancements throughout the value chain. Environmental concerns which encourage carbon emission reduction, the need for cleaner production processes, sustainable mobility and transportation logistics, end of product life waste reduction, recycling and reuse, have the potential to increase costs for many businesses but can also lead to cost savings in many circumstances. Productivity improvements through improved efficiency can result in higher net margins combined with lower environmental impacts, as highlighted by Kreuze and Newell (1994) using activity-based costing over the life cycle of products.

Sixth, the scope for efficiency gains is increased where business is conducted across a broader range of countries, but the risks of a strategic problem arising are greater. For example, redirecting energy sourcing towards non-fossil fuels is a policy adopted by many countries with a target to achieve Kyoto Protocol commitments. However, such gains could easily be lost as the costs of political risks associated with breakdowns in the rule of law in some countries overwhelm expected efficiency improvements.

These considerations of scope, cooperation, equity in the distribution of gains, industry structure, efficiency savings and the geographical dispersion of business lead to the notion of supply chain management as being: the cooperative coordination of business within a particular company and across separate businesses, for the purposes of improving the equitable and efficient long-term performance of the individual company processes and products across the global supply chain as a whole.

5 Supply Chain Environmental Management Accounting

An additional dimension to consider in relation to supply chain management is linkages with the environment and with management accounting. This leads to the notion of *supply chain environmental management accounting* which is now addressed.

Accounting for the environment has been systematically studied by researchers since the late twentieth century, either separately or as part of sustainability accounting (e.g. Gray et al. 1993, Schaltegger and Sturm 1992, Schaltegger and Burritt 2000, Lamberton 2005, Burnett and Hansen 2008, Schaltegger and Burritt 2010). In parallel has been the development of stakeholder management by business through the provision of environmental information in order to improve corporate economic and environmental performance and accountability (Fassin 2009). Accounting for the environment is widely accepted as comprising two parts, external environmental financial accounting and internal EMA (Schaltegger and Burritt 2000). Burritt et al. (2002) provide a comprehensive framework for developing an understanding of the breadth of tools and activities associated with EMA which in essence identifies typical decision settings for which environmental information is necessary. Given access to the relevant environmental information through EMA, managers can make informed decisions about environmental and economic matters which affect their organisations. The level of sophistication provided by EMA support depends on the needs of the manager, the industry, the size of organisation, the scope of activities, whether the decision affects the short run or long run, the frequency of data needs and the measurement system.

This book considers the question of the links between EMA and supply chain management.

All the boxes in Table 1.1 represent potential tools for supporting supply chain EMA. Not every chapter in this volume necessarily addresses a specific EMA tool directly, but they all have implications for the best choice of tools in a particular situation. Table 1.2 accordingly shows how each chapter is located on this matrix, e.g. in Chap. 2, Viere et al. demonstrate how four interrelated ad hoc tools are used by a coffee exporter in the context of short and long-term decision-making. Each situation differs from the next, but this comprehensive framework facilitates the identification and analysis of corporate decision settings involving supply chain management issues.

The analysis begins by first identifying the relationship between parties in the supply chain, the decision setting, the type of managers involved and the information which is needed. Hence, in a simple three party setting the framework extension illustrated in Table 1.3 would be applicable. The important additional dimensions in supply chain EMA include: the number of parties in the supply chain; the flow of goods and services; the flow of net benefits; the type of integration, bearing in mind that each part of the supply chain may face different types of integration; how eco-efficiency, eco-effectiveness and eco-equity are to be measured and finally, the number of countries involved.

Table 1.1 Comprehensive environmental management and sustainability accounting framework

<table>
<tr><th></th><th></th><th colspan="2">Monetary EMA</th><th colspan="2">Physical EMA</th></tr>
<tr><th></th><th></th><th>Short-term</th><th>Long-term</th><th>Short-term</th><th>Long-term</th></tr>
<tr><td rowspan="2">Past or present oriented</td><td>Routinely generated</td><td>Env. cost accounting</td><td>Env. induced capital expenditure and revenues</td><td>Material and energy flow accounting</td><td>Env. capital impact accounting</td></tr>
<tr><td>Ad hoc</td><td>Ex post assessment of relevant env. costing decisions</td><td>Post-investment assessment of individual projects</td><td>Ex-post assessment of short-term env. impacts</td><td>Post-investment appraisal of physical env. investment</td></tr>
<tr><td rowspan="2">Future oriented</td><td>Routinely generated</td><td>Monetary env. budgeting</td><td>Env. long-term financial planning</td><td>Physical env. budgeting</td><td>Long-term physical env. planning</td></tr>
<tr><td>Ad hoc</td><td>Relevant env. costing</td><td>Monetary env. project investment appraisal</td><td>Tools designed to predict relevant env. Impacts</td><td>Physical env. Investment appraisal</td></tr>
</table>

Source: Burritt et al. (2002)

6 Structure of the Book

This fifth volume in the EMAN series presents a collection of research papers on EMA within the contexts of supply chain environmental management, corporate social responsibility, and the integration of accounting, organised into five parts. Part I provides the introduction to relationships between EMA and Supply Chain Management as well as the structure of contributions to the book. Part II addresses contemporary issues in sustainable supply chain management and EMA; Part III adopts a social focus; Part IV discusses matters with an economic focus, especially the issue of economic costs; and Part V compares benefits and costs and further examines issues associated with the development of the EMA framework. The following section provides a brief summary and review of each paper.

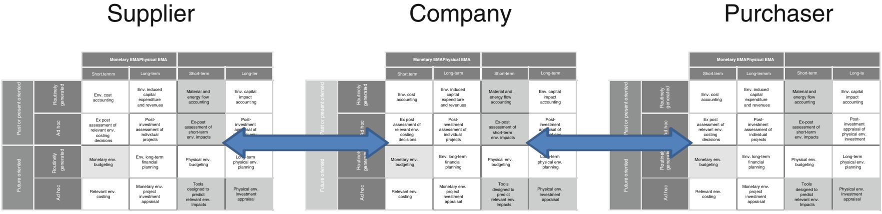
Part II opens the collection with papers on a number of topics related to contemporary issues in sustainable supply chain management and EMA.

In Chap. 2, Tobias Viere, *Jan von Enden* and *Stefan Schaltegger* consider life cycle and supply chain information in EMA. Using a case study of a medium-sized coffee refining and exporting company in southern Vietnam, the relevance of environment-related supply chain information derived from life cycle assessments for EMA is examined, revealing possibilities for improving eco-efficiency at both site level and for its supply chain. The case study reveals the importance of environment-related supply chain information for corporate decision-making. EMA can use tools such as Life Cycle Assessment to satisfy the demand for environmental information. In contrast to still-growing niche market solutions such as fair trade

Table 1.2 Tools used in EMA and Supply Chain Management chapters based on comprehensive framework

		Monetary EMA		Physical EMA	
		Short-term	Long-term	Short-term	Long-term
Past or present oriented	Routinely generated	3 Sustainable Purchasing 5 Risk analysis milk process 8 Social impact measurement 10 Carbon accounting 11 Macro–micro links 15 Sustainability management control	3 Sustainable Purchasing 8 Social impact measurement 11 Macro–micro links 15 Sustainability management control	3 Sustainable Purchasing 5 Risk analysis milk process 8 Social impact measurement 11 Macro–micro links	3 Sustainable Purchasing 8 Social impact measurement 11 Macro–micro links
	Ad hoc	2 Supply chain coffee 8 Social impact measurement 11 Macro–micro links	2 Supply chain coffee 8 Social impact measurement 11 Macro–micro links	2 Supply chain coffee 8 Social impact measurement 11 Macro–micro links	2 Supply chain coffee 8 Social impact measurement 11 Macro–micro links
Future oriented	Routinely generated	6 Stakeholder engagement 8 Social impact measurement 11 Macro–micro links 12 Environmental benefits	6 Stakeholder engagement 8 Social impact measurement 11 Macro–micro links 15 Sustainability management control 16 International chemicals assessments	6 Stakeholder engagement 8 Social impact measurement 11 Macro–micro links 12 Environmental benefits 16 International chemicals assessments	6 Stakeholder engagement 8 Social impact measurement 11 Macro–micro links
	Ad hoc	3 Sustainable Purchasing 8 Social impact measurement 10 Carbon accounting 11 Macro–micro links 12 Environmental benefits	3 Sustainable Purchasing 7 CSR competitiveness 8 Social impact measurement 9 Environmental capital investment 10 Carbon accounting 11 Macro–micro links 13 Water cost–benefit analysis 14 Chemical costs in oilfields 16 International chemicals assessments	3 Sustainable Purchasing 8 Social impact measurement 11 Macro–micro links 12 Environmental benefits 16 International chemicals assessments	3 Sustainable Purchasing 7 CSR competitiveness 8 Social impact measurement 9 Environmental capital investment 11 Macro–micro links 13 Water cost–benefit analysis 14 Chemical costs in oilfields

Table 1.3 Comprehensive EMA framework and supply chain – three parties in a single country



Source: Adapted from Burritt et al. (2002) arrows represent flow of goods, information and money

and organic coffee farming, supply chain eco-efficiency measures show potential for use within the mass market of Vietnamese coffee production. Life cycle assessment is undertaken from time to time in an ad hoc manner to examine short-term physical environmental flows as well as a monetary equivalent.

In Chap. 3, Gyöngyi Vörösmarty, Imre Dobos and *Tünde Tátrai* focus on one important part of the supply chain sustainable purchasing, and the motivations for adopting it. A framework for sustainable purchasing is developed from the literature which incorporates green, social responsibility, and corporate growth issues. This framework serves as the basis for an empirical interview-based investigation of the practices of thirteen Hungarian companies. The results validate use of the proposed framework and find that the type of motivation (whether this is primarily to avoid negative effects, to comply with expectations, or to attain positive effects) determines the number and type of sustainability activities of the companies. The paper concludes that purchasing tends to be a short-run regular activity but also needs to take long-run considerations into account relating to sustainability issues in making the purchasing process greener. The model which is developed examines physical and monetary flows of information.

In Chap. 4, Ettore Settanni, *Giuseppe Tassielli* and *Bruno Notarnicola* develop an input–output technological model of life cycle costing from a generalised supply-chain perspective for environmental capital investment. With material and cost flows playing an important role within manufacturing systems, structural interdependences between production processes in the supply chain need to be taken into account. A deconstruction and reconstruction of the input–output model to incorporate environmental costs is performed, in order to create a technological model which provides a computational structure which takes into account structural interdependencies in the production processes and environmental costs.

In Chap. 5, Jarkko Leppälä, *Esa Manninen* and *Tuula Pohjola* consider farm risk management and its application to sustainability and food supply chains. A case study of sustainability risks in dairy farming in Finland and the European Union explores various risks – financial, environmental and social – and uses these to evaluate the sustainability of dairy farm milking processes. Using force field analysis, the views of the farm manager are compared with the demands of the dairy supply chain. Factors and tasks critical to the economic, environmental and social sustainability of the dairy supply process are highlighted and the process risk analysis tools used here provide an example of a sustainability risks accounting system useful for small firm management. Tools implicit in the study relate to regular short-term risk analysis in physical and monetary terms for the dairy farm milking process associated with monitoring quality of food products and the related effect on profitability.

Part III has a specifically social focus, drawing on debates from the ever-growing corporate social responsibility and stakeholder engagement literature.

In Chap. 6, György Málovics, *Izabella Szakálné Kanó* and *Szabolcs Imreh* explore companies, stakeholders and corporate sustainability in Hungary. They examine the argument for corporate sustainability's link to macro-level sustainability and note the need for a radical change in the 'mainstream' paradigm for global sustainability to be achieved. Stakeholder engagement as a tool for corporate sustainability is examined in the Hungarian context. The paper concludes that in Hungary it is unclear whether present market circumstances and stakeholder pressures motivate or even allow businesses to move towards sustainability. They argue that stakeholder engagement may not be the panacea for corporate sustainability that it is argued to be, and that before placing too much emphasis on stakeholder engagement's role in organisational sustainability, it is necessary to analyse the possibilities and shortcomings. The natural environment is found to be the most consistent critical concern for most parties (employees, local communities and consumers), which implies that environmental issues should be of concern to managers seeking information, and this means that routine physical information about quality is likely to be considered important, as are cost savings, in engaging employees and customers.

In Chap. 7, Torsti Loikkanen and *Kirsi Hyytinen* explore corporate social responsibility and competitiveness in the era of globalisation. The aim of this set of case studies is to produce knowledge about the state and objectives of corporate social responsibility in the context of competitiveness. Case studies were carried out by interviewing 27 executive-level representatives of the case firms. The methodology used in most case studies was focus group interview, supplemented by individual interviews. The relationship between corporate social responsibility and competitiveness is revealed to be complex; benefits from investment in corporate social responsibility may arise in the long term, and the relationship is found to be positive with the social aspects of a company's activities found to be the most important, so there are information needs associated with long-term physical and monetary information for companies wishing to make gains.

In Chap. 8, Karen Maas explores social impact measurement and provides an analysis of 30 available contemporary methods. She finds that social impact measurement methods differ in terms of their purpose, time frame, orientation, length of time frame, perspective and approach. She develops a classification system which allows managers to understand the various measurement methods and their limitations in the face of a lack of consensus on the definition of social impact. The paper notes that of the 30 methods examined, only 8 measure social impact, so that there is a need for a social impact method which measures the impact of single activities, has an output orientation and concentrates on longer-term effects.

Part IV presents a set of papers that take an economic focus on EMA through the lenses of capital investment decisions, carbon accounting and the importance of micro–macro distinctions in EMA.

In Chap. 9, Norio Minato considers a new decision-making method for capital investment for environmentally friendly products. This method enables management decisions to be made under highly volatile conditions whilst promoting corporate environmental behaviour. There are two challenges in establishing a decision-making method for environmentally friendly projects: firstly to create corporate value by reducing environmental impacts, and secondly to incorporate management decision flexibility into the appraisal of environmental investments. The paper proposes a new method of environmental investment decision-making which it then applies to a hybrid vehicle project. The results show that a project which had appeared unattractive when evaluated using existing methods was shown to be attractive when this method was applied. The method potentially contributes to the promotion of innovative environmentally friendly projects by providing an alternative decision-making framework.

In Chap. 10, Benjamin Karatzoglou and *Ourania Karatzoglou* consider carbon accounting in Greek companies participating in the European Union's Emissions Trading Scheme. A major finding is that Greek participants to the Scheme, just like their European Union counterparts, treat the accounting entries related to their allowances in an arbitrary way. They ignore the IFRIC3 accounting standard (which although it has been withdrawn nevertheless still offers useful guidance) as well as relevant academic recommendations. Companies currently attempt to exploit the scheme as a means for gaining windfall profits rather than as a transient tool to prepare themselves for the auctioning phase which is expected to follow. Taking advantage of their oligopolistic situation, they are considering how to pass on future expenses of the Scheme to consumers. The result is that in contrast to the original intention of the Scheme, in the end neither the environment nor the businesses gain.

In Chap. 11, Christine Jasch considers the micro and macro level requirements of EMA from the practitioner's perspective. The paper compares the System of Environmental–Economic Accounting disclosure requirements and the guidance document on EMA published by IFAC and discusses the definitions used in each document, and explores the differences in the approaches to environmental protection and integrated pollution prevention which underpin them. It offers recommendations for harmonisation and their incorporation into the review process of the System of Environmental–Economic Accounting.

Part V brings together consideration of the benefits and costs of environmental activities in a number of different contexts: company value, value to society of water quality, value in a construction project in the context of chemical use, internal value through strategic management control and external value through improved regulation.

In Chap. 12, Hajnalka Ván and *Szilvia Gärtner* examine the benefit of environmental activities and their connection to company value. With EMA focussed more on costs than benefits, environmental benefits have tended to be regarded as focusing on only cost reduction, or as providing only a very limited opportunity for creating revenues. However, the profitability of environmental activities represents a very important question for firms. The paper argues that the positive effect of an environmental activity can involve a wide range of intangibles such as higher brand value, competitive advantages and lower levels of operational costs. Information flows relate largely to the regular gathering of short-run monetary benefits of inbound logistics, operations, outbound logistics, marketing, sales and services and four support activities (infrastructure, human resource management, technology development and procurement).

In Chap. 13, Zsuzsanna Marjainé Szerényi, *Ágnes Zsóka* and *Judit Rákosi* look at the implementation of the European Union's Water Framework Directive in Hungary. This pilot study explores the Directive's requirements and its estimate of the economic benefits resulting from the improvement of water quality and condition. Contingent valuation is used in two areas, the natural river Túr and the artificial Kállay Channel. It is found that there is a similar willingness to pay by households; only a small proportion of monthly income would be dedicated to improving bodies of water. The results of the survey can be used primarily in cost–benefit analyses to provide a basis for future programmes as well as in coordinating international efforts for improving the water quality of catchment areas.

In Chap. 14, Ylva Gilbert and *Anna Kumpulainen* examine health, safety and environmental consequences and risks associated with an oil well construction project. Here they develop a new method and tool for assessing the overall costs of chemical use within the project. The method combines predicted health, safety and environmental costs with direct operating cost consequences of chemical hazard profiles. Using a comparison between two high-density completion brines, the tool allows EMA principles to be used as input during the project's planning and purchasing stages, which presents a significant advancement in making EMA principles accessible for everyday decision-making.

In Chap. 15, Stefan Schaltegger examines sustainability management control in an era where sustainability is a driver of both risks and opportunities. His paper argues for a more systematic approach to information management than current approaches that in practice involve working with checklists. Using the core logic of the Sustainability Balanced Scorecard (SBSC) perspectives, a multifaceted concept for sustainability management control is proposed which works with specifically derived indicators in five different areas of management control relating to financial, market, process, people and non-market issues.

In Chap. 16, Anna Széchy explores impact assessment in European Union decision-making. Impact assessments have been increasingly used to improve the regulatory environment but the process of monetarisation in the field of environmental legislation has the potential to undermine unbiased outcomes. This paper uses the Registration, Evaluation and Authorisation of Chemicals (REACH), the European Union's new chemicals policy, as a case study of impact assessment. It finds that although it underpins the expected positive overall outcome of regulation, the uncertainty involved in estimating the benefits results in limited applicability of the impact assessment's findings in the decision-making process, and contributes to the fact that REACH was finally adopted with substantially lower requirements than originally planned.

References

Boyd DE, Spekman RE, Kamauff JW and Werhane P (2007) Corporate social responsibility in global supply chains: a procedural justice perspective *Long Range Planning* 40.3 341–356

Burnett R and Hansen D (2008) Eco-efficiency: a role for environmental cost management *Accounting, Organizations and Society* 33.6 551–581

Burritt RL, Hahn T and Schaltegger S (2002) Towards a comprehensive framework for Environmental Management Accounting. Links between Business actors and Environmental Management Accounting Tools *Australian Accounting Review* 12.2 39–50

Fassin Y (2009) The stakeholder model refined *Journal of Business Ethics* 84.1 113–135

Fox A (1974) *Beyond contract: Work, power and trust relationships*, Society Today and Tomorrow Series London,Faber

Garnaut J and Liu S (2010) Stern sentenced to 10 years by Chinese court *The Age*, Retrieved 29 March 2010

Gray R, Bebbington J and Walters D (1993) *Accounting for the Environment* London, Paul Chapman

Kaipia R (2009) Coordinating material and information flows with supply chain planning *The International Journal of Logistics Management* 20.1 144–162

Kreuze J and Newell G (1994) ABC and life-cycle costing for environmental expenditures. The combination gives companies a more accurate snapshot *Management Accounting US* 75.8 38–42

Lamberton G (2005) Sustainability accounting – a brief history and conceptual framework. *Accounting Forum* 29 7–6

Linton D, Klassen RB and Jayaraman V (2007) Sustainable supply chains: an introduction *Journal of Operations Management* 25.6 1075–1082

Mentzner JT, DeWitt W, Keebler JS, Min S, Nix NW, Smith CD and Zacharia ZG (2001) Defining Supply Chain Management *Journal of Business Logistics* 22.2 1–25

Pereira JV (2009) The new supply chain's frontier: information management *International Journal of Information Management* 29.5 372–379

Schaltegger S (1998) Accounting for eco-efficiency *in* Nath B, Hens L, Compton P and Devuyst D (Eds.) *Environmental Management in Practice. Volume1*, London, Routledge 272–287. Reprinted in: Bartelmus P and Seifert E (Eds.) (2002) Green Accounting Aldershot, Ashgate Publishing 287–302

Schaltegger S and Burritt RL (2000) *Contemporary Environmental Accounting* Sheffield, Greenleaf Publishing

Schaltegger S and Burritt RL (2010) Sustainability accounting for companies: catchphrase or decision support for business leaders? *Journal of World Business* 45.4 375–384

Schaltegger S and Sturm A (1992) *ökologieorientierte Entscheidungen in Unternehmen. ökologisches Rechnungswesen statt ökobilanzierung (in German: Ecologically oriented Decisions in Companies. Ecological Accounting instead of Ecobalancing)* Bern, Haupt

Seuring S and Muller M (2008) From a literature review to a conceptual framework for sustainable supply chain management *Journal of Cleaner Production* 16 1699–1710

Shank JK and Govindarajan V (1992) Strategic cost analysis of technological investments *Sloan Management Review* 34.1 39–51

Spector B (Ed.) (2005) *Fighting Corruption in Developing Countries: Strategies and Analysis* Bloomfield, Kumarian Press

Part II
Contemporary Issues

Chapter 2
Life Cycle and Supply Chain Information in Environmental Management Accounting: A Coffee Case Study

Tobias Viere, Jan von Enden, and Stefan Schaltegger

Abstract This case study illustrates the application of environmental management accounting in a medium-sized coffee refining and exporting enterprise in Southern Vietnam, with the example of the Neumann Gruppe Vietnam Ltd. It examines the relevance of environment-related supply chain information derived from life cycle assessments for environmental management accounting and reveals possibilities to improve eco-efficiency at the site level and for its supply chain.

All company-related information provided in this case study has been disclosed by Neumann Gruppe Vietnam Ltd. and cross-checked by the authors. The information is partly simplified to ensure both confidentiality and a better understanding of the case.

Keywords Coffee • Supply chain • Environmental management accounting • Vietnam • Eco-efficiency • Supply chain costing • Supply chain management • Life cycle assessment

1 Introduction

This paper presents a case study on environmental management accounting, which has been conducted under the InWEnt-funded capacity development project 'Environmental Management Accounting for small and medium-sized enterprises

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in South-East Asia' (InWEnt 2008). The study was conducted at Neumann Kaffee Vietnam Ltd, a coffee refining and exporting company. To understand better the case study setting, the paper provides an overview of the economic and environmental situation of the Vietnamese coffee business and reveals relevant results of life cycle assessments on coffee. Combined with specific information on the company's environmental and business performance, the environmental decision-making situation and potential consequences are discussed. Special attention is paid to the relevance of supply chain information and life cycle assessment results for environmental management accounting.

2 Environmental Management Accounting and Life Cycle Information

The basic task of management accounting is to provide information to managers and other internal stakeholders for their decision-making, e.g. product and production cost, budgets, investment appraisals or benchmarks. In contrast with financial accounting, which discloses mainly standardised and often mandatory information to external stakeholders such as shareholders, stockholders, creditors or tax authorities; management accounting is a voluntary function used to improve business performance (Atkinson et al. 2007, Hansen and Mowen 2006, Horngren et al. 2008).

Environmental accounting has evolved because of insufficient consideration of environmental impacts and their financial consequences in conventional accounting (Schaltegger and Burritt 2000). In accordance with general accounting, environmental accounting can be categorised into financial and management accounting, with environmental management accounting (EMA) primarily supporting decision-making by internal stakeholders (Burritt et al. 2002). This being the case, EMA has potential application in various business decision-making situations and therefore comprises different tools and measures. Indeed, various academic papers deal with different decision-making situations and contribute to their further exploration. For instance, Burritt (2005) examines EMA in a risk management context and Figge et al. (2003) and Dyllick and Schaltegger (2001) propose a Sustainability Balanced Scorecard (SBSC) to link EMA and strategic management. Burritt et al. (2002) propose a framework which allows classifying EMA decision settings systematically depending on the type of information required by the decision maker. They distinguish monetary or physical, long term or short term-focussed, ad hoc or routinely generated, and past or future-oriented information (Burritt et al. 2002).

Most papers dealing with the actual implementation of environmental management accounting, however, focus mainly on environmental cost accounting applications, i.e. the provision of short-term focussed, routinely generated, past-orientated, monetary environment-related information for decision-making (see the ensemble of contributions in Bennett et al. 2002, 2003, Rikhardsson et al. 2005 and Schaltegger et al. 2006). Likewise, international guidelines on EMA published by

International Federation of Accountants (IFAC) mention the range of EMA decision settings, but concentrate on an environmental costing approach (IFAC 2005).

Restricting EMA to internal environmental cost accounting seems to be inappropriate from a supply chain perspective. If companies aim at improving their supply chains toward sustainable development, environmental and economic information on supply chain steps external to the company is required. As a consequence, life cycle assessment (LCA) and environmental life cycle costing become crucial EMA tools to improve the supply chains. These EMA tools provide the adequate information for supply chain-specific decision settings (Burritt et al. 2002; for an introduction to LCA and environmental life cycle costing see Guinée 2002, Hunkeler et al. 2008). Therefore, this case study pays special attention to life cycle aspects relevant for managerial decision-making.

3 Case Study Background: The Coffee Market

Coffee is one of the most valuable traded commodities in the world. Until the late 1990s it was even the second most valuable commodity after oil (Ponte 2004). Vietnam is a newcomer on the international coffee market and has experienced a rapid growth of coffee farming for the last two decades. This rise has not only made Vietnam the second biggest coffee exporter after Brazil, but it has also contributed to shrinking prices and ever-increasing competition in the world market. Since 1970, the average annual price decline has been 3% for Arabica and 5% for Robusta coffees (Lewin et al. 2004).

Globally, the declining prices are associated with rising unemployment and poverty in some of the coffee exporting countries. At the same time, the profits made in the coffee importing countries have remained stable or even increased due to the introduction of new brands and blends and other value-adding activities (Lewin et al. 2004). Thus Ponte (2004) characterises the coffee supply chain as a buyer-driven or more specifically as a ‘roaster-driven’ one.

Vietnam is a mass producer of coffee, not a quality leader. Robusta, the main type of coffee produced in the country, is considered less valuable than Arabica, which is the main type of coffee produced in most other countries. Robusta achieves lower prices in the world market and is mostly used as admixture to downmarket coffee products. Many consumers prefer the taste of Arabica, except for certain types of espresso. Hence, Vietnam’s current competitive situation is a purely price-driven one; it needs to produce a cheap type of coffee for the mass market at lowest possible costs. It should be noted, though, that there are initiatives to change this situation, for instance, the Vietnamese Ministry of Agriculture is planning to increase the production of Arabica coffee, to improve the quality of coffee processing and to participate more actively in international coffee trading (People’s Daily Online, 9th May 2006). This might lead to the development of higher-quality grades in the future, which are less dependent on the fluctuating world market prices. At present, the world market prices have risen, relieving news for Vietnamese coffee production (Flexnews, 26th March 2007).

Coffee is a typical example of a global commodity. Mainly produced in developing nations in tropical areas, however, the majority of consumers can be found in industrialised countries. Highly efficient consumer markets and the large corporate wholesalers, roasters, and traders buy coffee from agricultural smallholders and middlemen. The widely spread perception of the global value chain of coffee is one where profits are made in industrialised countries at the expense of environmental and social problems in the developing world. This has lead to initiatives promoting fair trade and sustainable coffee farming including organic, shade-grown and bird-friendly coffee products. The market share of organic and fair trade coffee is continuously increasing; however, it is still less than 2% of the world market (Ponte 2004).

Doubtlessly, the cultivation and processing of coffee has severe environmental consequences. Deforestation, loss of biodiversity, eutrophication, depletion of water and energy resources, and erosion are examples of environmental impacts associated with the first steps of the coffee supply chain. Plentiful measures to reduce these impacts are available, for instance, shade grown and organic cultivation, diversification and alternating vegetation, fallowing, planting of grass under the coffee plants, recycling of wastewater, composting of other waste, etc. These measures are perceived as costly and therefore, the fierce price competition drives harmful practices (Clay 2004).

Admittedly, it cannot be concluded that less intense competition would automatically lead to less harmful practices. On the contrary, high world market prices and profit margins encouraged Vietnamese authorities to promote coffee farming since the late 1980s and stimulated the interest of many Vietnamese to take their chance in coffee farming. Without knowing much about coffee cultivation, harvesting and processing, this boost lead to deforestation, soil degradation, over-fertilisation and further environmental impacts (Johnston 2001).

The stages of the coffee supply chain and the associated environmental issues will be elaborated further. Improvement options will be derived from a review of life cycle assessments on coffee.

3.1 Environmental Issues in the Coffee Supply Chain

The coffee supply chain starts with agricultural processes in tropical countries and ends with the consumption and disposal stages, predominantly in industrialised countries in cooler latitudes. The main stages and environmental impacts are highlighted in Fig. 2.1 and comprise (ICO 2001):

- *Coffee cultivation*: Coffee farmers and hired workers plant coffee trees, apply fertiliser, pesticides and herbicides, irrigate the plants and finally harvest coffee cherries. These activities are associated with soil erosion and loss of biodiversity

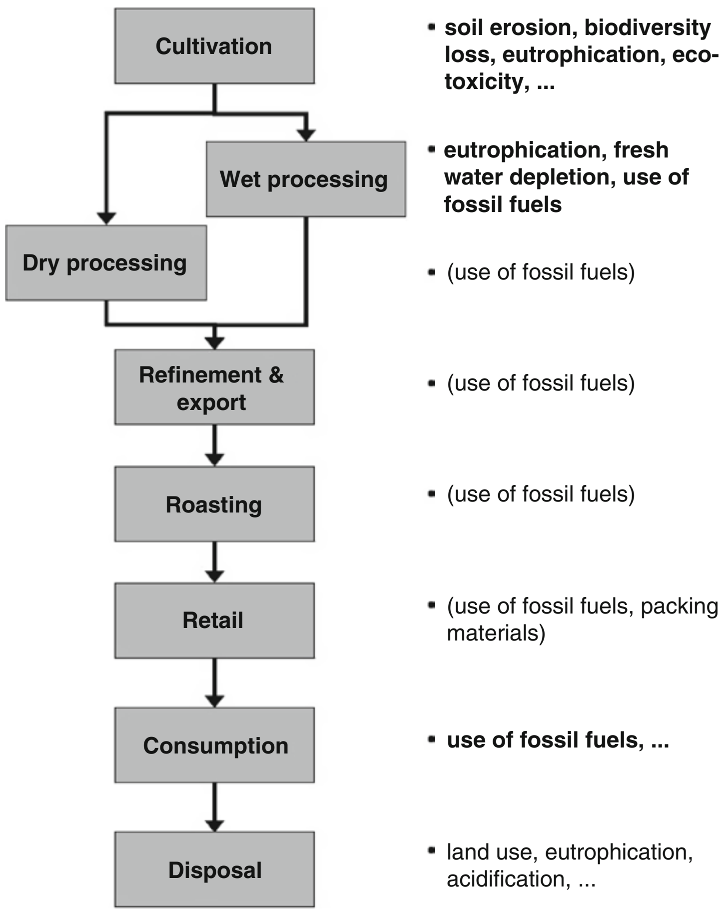

Fig. 2.1 Coffee supply chain stages and environmental issues

due to the extension of agricultural land use; eutrophication, eco-toxicity and greenhouse effect due to fertilisation; mammal and aquatic life toxicity due to pesticide use; and resource depletion due to the fuel and water consumption required for farming.

- *Dry/wet processing*: The coffee cherries have to be processed to release the green coffee beans. Robusta coffee cherries are usually treated by using the dry processing method; most Arabica coffees are wet processed. Dry processing can be achieved by solar power (sun-drying) or by the use of fuels; the latter one is more common in Vietnam. After drying, the coffee cherries are hulled and ground to release the green coffee bean. The waste of this process, dried pulp and parchment skin, can be composted. Wet processing is more harmful from an environmental point of view, but gains higher selling prices for the coffee beans.

The traditional wet processing method requires 40,000–70,000 l of water input per tonne (ton) of green bean; the mechanical removal of mucilage (coffee fibre) reduces this demand down to 1,000 l. The organic pollutant load of the generated waste water is similar in both cases. BOD and COD of wet processing waste-water are extremely high, while the pH is low. Untreated waste-water of wet processing is therefore a major driver of environmental problems caused by the production of coffee.

- *Coffee refinement and export*: Coffee beans are not homogeneous, e.g. they vary in size, shape, colour and/or moisture content. To separate and to improve quality grades, a variety of measures are applied in the refining step: polishing, sorting, washing and drying. The coffee-producing countries export most of their coffee to industrialised countries. Both, the refinement process and coffee export require energy, either in the form of electricity or fuel input.
- *Coffee roasting and retail*: To roast the green coffee beans, thermal energy is required. This thermal energy can cause air emissions including greenhouse gases. Decaffeinated and soluble coffee in particular require water in the roasting process as well. After roasting, coffee needs to be packed. Polyethylene foil (PET) is used for packing to ensure that no oxygen reacts with the coffee to avoid ageing. Other packaging types are glasses with screw caps for soluble coffees. Roasting does not necessarily happen after export, it is also common to export roasted coffee.
- *Consumption*: Energy consumption is the most important environmental issue of this step of the coffee life cycle. The making of coffee requires energy, mainly electricity, for the percolator. The habit of leaving coffee on the hot plate of the percolator to keep it warm increases the energy demand further. Of course, coffee-making involves a certain amount of water input as well.
- *Disposal*: Consumers need to dispose coffee grounds and filters as well as the packaging. Coffee grounds and filters are often composted, but have a comparably long and irregular rotting process. Packaging as well as jute and plastic bags from previous supply chain steps is recycled, incinerated or dumped. The common environmental problems related to waste treatment like energy consumption, acidification and greenhouse gas emissions are therefore present.
- *Transportation*: Transportation is not depicted in Fig. 2.1, as it occurs between almost all steps of the coffee life cycle. The biggest transportation distance concerns the shipping of green beans or roasted coffee from the producing to the consuming countries. Transportation is associated with the depletion of natural resources, in particular fossil fuels, and the environmental impacts of combusting the fuels, most prominently global warming.
- While coffee farming, the supply chain's first step, is often in the spotlight of environmental attention, later steps of the value chain tend to be disregarded. However, life cycle analyses (LCA) of coffee production conducted by Diers et al. (1999) and Salomone (2003) show that another crucial step of coffee production is coffee consumption.

3.2 Environmental Supply Chain Improvements – Conclusions from Life Cycle Assessments on Coffee

An LCA can be used to highlight the environmental importance of different steps of a product's life cycle. Two LCAs have been conducted for coffee production (Diers et al. 1999, Salomone 2003). Looking for the highest overall improvement potential of the coffee life cycle, the conclusion of both LCAs is similar: the first and the last steps of the life cycle matter most.

Salomone (2003) identifies consumption as the single most important step followed by cultivation. Cultivation accounts for more than 97% of coffee's total eco-toxicity and eutrophication, while consumption, comprising mainly the water use and energy demand for preparing coffee, accounts for more than two thirds of total air acidification, greenhouse effects, photochemical oxidant formation, depletion of ozone layer, human toxicity, and aquatic eco-toxicity. The importance of the consumption step for the overall environmental performance of coffee production is supported by the results of a sensitivity analysis. It reveals that in terms of overall environmental impact, the impact of changing the coffee-making process, e.g. gas stove coffee-making instead of an electric coffee machine, is substantially higher than the impact of avoiding pesticides or applying organic fertilisers in cultivation (Salomone 2003).

In the analysis of Diers et al. (1999), coffee cultivation and processing account for 49%, and consumption and disposal for 41% of the environmental impacts. Furthermore, a comparison of best case, worst case and the current situation places the current situation near to the worst case scenario, meaning that the improvement potential of the coffee life cycle is rather high (Diers et al. 1999). The coffee processing step has a higher impact in this analysis due to the fact that wet and dry processing have been considered, while Salomone considers dry processing only. Similarly, the analysis of Diers et al. is stressing the waste disposal issue more than Salomone does which leads to a slightly higher importance of the disposal stage. Both LCAs do not explicitly consider loss of biodiversity, which is likely to increase the environmental importance of the cultivation step even further.

The results of the two LCAs help decision makers to prioritise options for environmental improvements of the supply chain (Diers et al. 1999, Salomone 2003):

- In *cultivation*, avoidance or reduction of fertiliser use is the most important concern followed by measures to avoid erosion. Preservation of biodiversity has not been considered in the LCAs, but is likely to be of importance in the Vietnamese coffee farming context as well.
- The impacts of *wet processing* can be substantially reduced by proper waste-water treatment and reduction of water consumption. In wet and dry processing, fuels are consumed for drying. Energy-efficiency measures could reduce environmental impacts like global warming and resource depletion.

- *Refinement*, export, roasting, retail and transportation are not the highest priority for environmental improvements of the coffee life cycle.
- In *consumption* eco-efficiency can be improved by using electricity from renewable resources or by substituting the coffee machines run by electric energy with different devices, e.g. plunger pots, which can use other less polluting energy sources like gas. A big improvement potential is the change of consumer habits which includes, for instance, the use of thermos cans or bottles instead of leaving the coffee on the hot plate for several minutes or the reduction of wastage caused by non-consumed coffee poured to the drainage.
- Coffee ground and coffee filters are the biggest contributors to environmental impacts of the *disposal* stage. Measures to ensure proper composting are likely to reduce these impacts substantially.

4 The EMA Case of a Vietnamese Coffee Exporter

Neumann Kaffee Gruppe (NKG) is one of the biggest coffee exporter and importer companies in the world. The group steers 47 companies in 28 countries from its headquarter in Hamburg, Germany. Besides its export business including quality milling and grading and its import and trade of industrial volumes, specialities and instant coffees, the NKG is also doing business in coffee farming, logistics, risk management and finance (Neumann Kaffee Gruppe 2008).

One of the group's subsidiaries, Neumann Gruppe Vietnam Ltd, is refining and exporting coffee to overseas roasters. The company has been subject to an EMA case study carried out by the authors of this paper as part of InWEnt's capacity development project 'Environmental Management Accounting for small and medium-sized enterprises in South-East Asia' (InWEnt 2008). The case study is part of a series of case studies that aim at identifying and analysing environment-related management decision settings in various South-East Asian businesses (Herzig et al. 2006).

4.1 Initial Situation

Neumann Gruppe Vietnam Ltd (called Neumann in the following) refines green Robusta coffee beans and exports to customers in several industrialised countries. Its customers expect a coffee quality which is above average and pay premiums for certain quality grades. Eighty employees work at Neumann's plant in Binh Doung Province, near to Ho Chi Minh City. The annual volume of sales is €12 million which correlates to the high value of the raw material; about 95% of the sales value comprises raw material purchasing costs. Competitors of Neumann are various Vietnam-based international, private and state-owned coffee exporters.

4.1.1 The Refinement Process

Neumann exports coffee beans of different quality grades. To produce these grades, the coffee beans are processed once or twice through the following refinement steps:

- *Coffee cleaning*: This basic cleaning step produces the lowest exportable quality grade of Robusta coffee beans. The step ensures that no kind of foreign matter is included in the exported products which could harm the customers' roasting devices.
- *Gravity sorting*: Neumann's customers pay a premium for deliveries of homogeneous coffee beans. This step allows Neumann to produce export coffee beans within a determined range of size.
- *Colour sorting*: Further value is added to the coffee beans if they consist of the same size and the same colour. Too dark beans are sorted out as they would otherwise deteriorate the quality of the roasted coffee at the customer's site.
- *Wet polishing*: This final step produces the highest quality of Robusta coffee beans by improving and harmonising the bean's surface.

The selling price for the different qualities of Robusta and the purchasing price for Robusta beans depend on the world market and the local supply. It varies from season to season or even shorter time scales due to international commodity trading. Assuming a rather high purchasing price of €1,000 per metric ton, the premium for refinement ranges from less than €5 per ton for cleaned beans to €60 per ton for wet polished Robusta.

4.1.2 Supply Chain Setting

Neumann is situated at the interface of smallholders and local companies on one side and multinationals and global competition for commodities on the other. Neumann's sales follow the demand and supply rules of international markets, while their procurement depends on the availability and quality of the local supply. The same appears for environmental and social issues: international requirements for more sustainable coffee production meet the local, not necessarily congruent, perception of environmental importance.

For several commodities Blowfield (2004) observed a gap between the sustainability or ethical standards of parts of the demand side and the values and priorities of producers in the chain. This is particularly true for the Vietnamese coffee chain. Neumann's customers, international coffee roasters and traders, are exposed to environmental and sustainability concerns in the coffee consuming countries. Many of the international roasters and traders have responded by establishing corporate social responsibility (CSR) departments, launching of codes of conduct, and offering fair trade and sustainable coffees. Neumann's suppliers, in contrast, face almost no direct pressure and get little incentive to change their current way of coffee mass production.

4.1.3 EMA Motivation and Decision Setting

Neumann's motivation for using EMA is to identify if and how environmental aspects are relevant for the business's success. The company's options to increase its business performance are related to the margin between the purchase price and the selling price of coffee. Three basic options to increase the value added can be distinguished and are linked to environmental issues:

1. *Gain premiums for better qualities of coffee*: Neumann is already refining Robusta coffee to benefit from premiums. The export of sustainable coffees might be a further option to receive premiums.: however, the supply and demand for sustainable, organic or fair trade Robusta coffee from Vietnam is negligible. Thus Neumann would have to stimulate the demand and the supply at the same time. Alternatively, Neumann could also try to export sustainable Arabica coffee from Vietnam.
2. *Reduce company-internal costs*: Considering the purchasing and selling price of coffee as fixed, Neumann could increase profits by reducing the costs of refining and exporting coffee. This includes measures to increase energy- and material-efficiency.
3. *Purchase price reduction*: Assuming unchanged selling prices, lower purchase prices add value to Neumann's operations. Eco-efficiency improvements in the supply chain might enable suppliers to reduce their production costs and prices.

Option 1 has not been considered further as the company is considering itself not to be in a strong enough position to foster the development of a market for sustainable coffee from Vietnam. Neumann's interest in analysing the relevance of environmental aspects on the production costs (option 2), can be characterised as an ad-hoc, short-term focussed analysis of available information. Referring to the EMA framework of Burritt et al. (2002) (Fig. 2.2) this decision-making situation is found in Box 3, supported by some related physical information (Box 11). Option 3 requires external, supply chain-related information. Influencing the

		Enviromental Management Accounting (EMA)			
		Monetary EMA (MEMA)		Physical EMA (PEMA)	
		Short Term Focus	Long Term Focus	Short Term Focus	Long Term Focus
Past Oriented	Routinely generated information	e.g. environmental cost accounting 1	e.g. environmental induced capital expenditure and revenues 2	e.g. material and energy flow accounting 9	e.g. natural capital impact accounting 10
	Ad hoc information	**e.g. ex post assessment of environmental costing decisions 3**	**e.g. environmental life cycle (and target) costing 4**	**e.g. ex post assessment of short term environmental impacts 11**	**e.g. life cycle inventories 12**
Future Oriented	Routinely generated information	e.g. monetary environmental operational and capital budgeting 5	e.g. environmental long term financial planning 6	e.g. physical environmental budgeting 13	e.g. long term physical environmental planning 14
	Ad hoc information	e.g. environmental job costing, environmental pricing 7	e.g. monetary environmental investment appraisal 8	e.g. short run environmental impacts 15	e.g. life cycle analysis of specific project 16

Fig. 2.2 EMA decision situation at Neumann Coffee Group (EMA framework adapted from Burritt et al. 2002)

eco-efficiency of the suppliers requires a rather strategic, long-term focussed approach. The environmental management accounting approach to provide adequate information for this decision-making situation refers to Boxes 4 and 12 of Fig. 2.2.

4.2 EMA Application

As detailed above, the EMA application at Neumann is expected to support two different decision-making situations: environment-related cost information on the refinement processes and eco-efficiency potentials within the supply chain (options 2 and 3 in Sect. 4.1.3).

4.2.1 Material- and Energy Flow-Based Cost Accounting of the Refinement Processes

The business of refining and exporting coffee is not known for environmental problems like air and water pollution or intensive energy and resource consumption. A rough analysis of Neumann's operations validated this presumption. Perceivable environmental issues at Neumann's site are energy consumption (electricity), solid waste and water consumption. Transportation has not been considered as it is outsourced to suppliers. The low impacts of the on-site environmental issues are highlighted by the following comparisons: for refining and exporting a metric tonne of green beans, Neumann uses 40 kWh of electric energy, while a Vietnamese company that cultivates and processes coffee consumes roughly 50 times more per t (Doan et al. 2003). Neumann's water demand for refining and exporting one tonne of green bean is 35 litres on average, while the upstream water demand for traditional wet processing of coffee can amount up to 70,000 l per tonne (ICO 2001). An overview of material and energy inputs and outputs can be found in Table 2.1 (please note that for confidentiality reasons, grade A, B, C and D is used instead of the actual product names for different qualities).

Table 2.1 Physical input/output table for 1 ton of green bean input (simplified)

Input		Output	
Item	Physical amount	Item	Physical amount
Green beans	1,000 kg	Green beans grade A	430 kg
Water	0.035 m^3	Green beans grade B	370 kg
Electric energy	40 kWh	Green beans grade C	60 kg
		Green beans grade D	55 kg
		Green beans for local market	75 kg
		Dust	2 kg
		Weight loss	8 kg
		Waste water	0.035 m^3

Table 2.2 Physical and monetary flows of green beans grade B (simplified)

		Current situation		Best case scenario	
		Physical amount	Monetary equivalent (€)	Physical amount	Monetary equivalent (€)
Wanted product	Green beans grade B	1,000 kg	1,040	1,000 kg	1,040
Unwanted product	Green beans grade D	60 kg	60	0 kg	0
	Beans for local market	10 kg	10	0 kg	0
Waste	Dust and weight loss	10 kg	0	0 kg	0
Raw material input	Green beans	1,080 kg	−1,080	1,000 kg	−1,000
Further input	Electric energy	25 kWh	−1.50	23 kWh	−1.40
Profit/loss[a]			28.50		39

[a]Not including depreciation, labour costs, and overhead costs like general administration costs, management salaries, etc.

The consideration of inputs and outputs shows rather low raw material losses; dust and weight losses due to further drying of the beans account for 1% of the total output only. Nevertheless, the financial relevance of these losses is not to be neglected. One percent loss equals one percent of the purchasing costs of green beans, which account for more than 95% of the total production costs. Furthermore, according to Neumann green beans grade D and green beans for local market need to be considered as unwanted products, as the selling price for these products is neither higher nor lower than the purchasing price. There is no value added for these products, therefore Neumann should aim at reducing the amount of these products as far as possible. To better understand the refinement process for the different grades, a product-specific material and energy flow-related cost accounting has been carried out to trace energy consumption as well as material losses to the different quality grades. As an example, Table 2.2 displays the material and energy flows and losses as well as the related revenues and expenses for grade B coffee beans.

In contrast to the very low and therefore insignificant energy costs (0.14% of total expenses), material losses and the production of lower-quality grades have financial implications. Assuming that it would be possible to produce grade B without producing lower-quality grades and wastes, the profit would increase by 37% or €10.50 per ton of final product (best case scenario in Table 2.2). These figures are fictive as it is not possible to fully eliminate lower-quality grades and waste. The quality of beans as well as the waste-generating moisture and dust content vary and depend largely on the supplier. Nevertheless, the results imply that paying premiums for high-quality supplies, which lead to less unwanted products and wastes, is profitable within a certain margin.

The material and energy flow-based cost accounting has proven most of Neumann's assumptions, in particular that the financial importance of energy and water consumption is rather low, while the quality of the purchased coffee affects the profitability of the business. Eco-efficiency improvements in the supply chain, however, seem to be of higher importance for Neumann's performance.

4.2.2 Environmental Supply Chain Costing and Management

From a decision-making point of view it is important to know at which steps of the coffee life cycle environmental improvements are most promising. Neumann operates in a highly competitive market, thus financial implications of environmental supply chain improvements are of great interest. Gathering, analysing and using supply chain cost information for managerial decision-making is not widely covered in the general management accounting literature. At least some authors have elaborated this topic in detail in particular in the context of logistics (Cullen et al. 1999, LaLonde and Pohlen 1996).

Supply chain costing provides information to determine the overall effectiveness of the supply chain, identify improvement opportunities, evaluate alternative supply chain structures and select supply chain partners. The implementation of supply chain costing is a difficult task as its benefits do not necessarily occur evenly throughout the chain (LaLonde and Pohlen 1996). 'The sharing of cost information may give away a hard-earned competitive advantage or provide negotiating leverage to their supply chain partners' (LaLonde and Pohlen 1996:4).

The environmental improvement priorities elaborated in Sect. 3.2 can be used to analyse supply chain costs. As Neumann is not considering itself in a position to affect the consumer behaviour or the disposal stage of the coffee life cycle, the environmental supply chain costing focuses on upstream stages, namely cultivation and processing. Figure 2.3 exemplifies the supply chain costing approach. It depicts hypothetical production costs and gross profits for the three supply chain stages: cultivation, processing and refining. The composition of production costs in cultivation, though, corresponds to an average Robusta coffee farm in Dak Lak Province of Vietnam as investigated by one of the authors (E.D.E. Consulting for Coffee 2003).

In cultivation, the use of fertilisers is costly and harmful for the environment. Figure 2.3 shows that fertilisers account for 38% of total cultivation production costs. Moreover, the majority of farmers have been found to use fertilisers inefficiently. Many farmers use more than twice as much fertiliser as necessary (E.D.E. Consulting for Coffee 2003). Hence, if farmers manage to use fertilisers in the best possible way, they could halve the costs for purchasing fertiliser and the related environmental impacts. This would reduce their total production costs by roughly 20%.

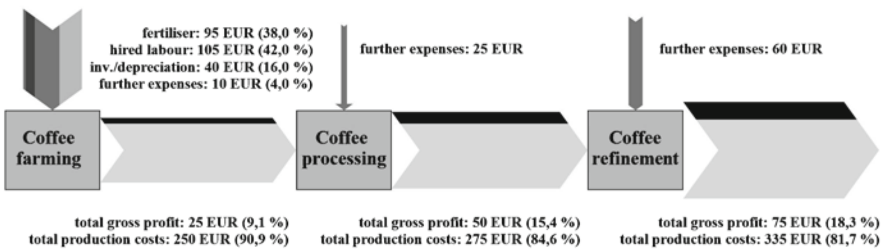

Fig. 2.3 Supply chain costing, current situation (hypothetical)

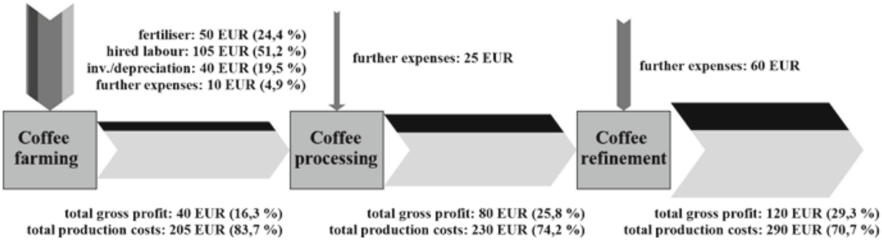

Fig. 2.4 Supply chain costing, adequate fertiliser use (hypothetical)

Figure 2.4 assumes that a supply chain management approach has been applied to increase eco-efficiency by using appropriate quantities of fertiliser, and that this eco-efficiency gain is shared among the three supply chain actors. At constant sales (€700), all three actors would increase their profits substantially due to the more eco-efficient use of fertilisers.

An environmental supply chain costing can also be used to reveal the additional benefits and costs of alternative, less damaging cultivation methods, for instance, by comparing the premiums paid for organic, shade-grown coffee and the consequent reduction of production costs with the reduced yields. In processing, the saving potential of more energy-efficient drying devices could be of interest, too.

The availability of supply chain cost information does not solve one major problem, though: 'restructuring the supply chain to exploit efficiencies or seize competitive advantages requires a mechanism capable of equitable allocating cost benefits and burdens between supply chain partners' (LaLonde and Pohlen 1996:8). Obviously, most Vietnamese farmers have not adapted methods for efficient fertiliser use by themselves. If one supply chain actor, like Neumann, starts to train farmers on more efficient use, it is not necessarily Neumann who benefits. The farmers may as well sell their coffee to other middlemen and exporters or just keep the farm gate price on the same level to make more profit. At first glance, the incentive for Neumann to facilitate eco-efficiency improvements within the supply chain is rather low.

A potential solution to overcome this dilemma is the application of environmental supply chain management. For Cooper et al. (1997a:68) supply chain management is 'an integrative philosophy to manage the total flow of a channel from earliest supplier of raw materials to the ultimate customer, and beyond, including the disposal process'. When taking the perspective of one company within the chain, the challenge is slightly different, though. In this perspective the supply chain looks not like a chain, but rather like an uprooted tree. The company needs to decide how many of the roots and branches it wants to manage (Cooper et al. 1997b:9). Seuring (2004) has compared different concepts of environmental management that address the flow of material and information along life cycles or supply chains. He concludes that out of all approaches assessed, environmental supply chain management is the most management-oriented approach.

For Neumann, the supply chain management challenge is to foster eco-efficiency improvements, in particular, reduced use of fertilisers at the coffee farming stage and to ensure participation in the financial benefits. According to Williamson (1975, 1985) the three basic options for co-ordinating supply chains are price (market arrangement), command and control (hierarchical arrangement) and negotiation (co-operative arrangement):

- Neumann could use *market arrangements to provide incentives*, or more precisely premiums to its supplier to receive higher qualities or special types of coffee, for instance, organic, fair trade coffees if there is a customer demand for it. Actually, this type of market arrangement is already used to ensure a certain quality level of the coffee bean supply. For the reduction of fertiliser use or other eco-efficiency measures in the upstream supply chain, market arrangements are not a promising option though. These measures benefit the farmer or middlemen only, but not Neumann.
- *Establishing hierarchical arrangements* is nearest to the original understanding of supply chain management, where rather large enterprises purchase key suppliers and own or control distribution channels. However, Neumann does not intend to acquire suppliers and is also not in a position to dominate the chain.
- *Cooperative arrangements* are the most promising option for Neumann. For instance, the company can offer its suppliers training and support on implementing eco-efficiency measures. In return, the suppliers need to agree to either pay Neumann for these services or to share their financial benefits. This kind of vertical co-operation is difficult to achieve as it requires monitoring the success of eco-efficiency measures and the adherence to contracts for all partners involved. Middlemen or farmers might take the opportunity to underestimate the savings or to sell parts of the harvest to other traders and exporters without Neumann Coffee's knowledge. Thus, horizontal cooperation, e.g. a joint initiative of all Vietnamese coffee exporters, seems to be the best available option. Higher energy-efficiency in dry processing and appropriate use of fertilisers lead to higher profitability and/or competitiveness of the Vietnamese coffee industry as a whole. Vietnamese coffee exporters, traders and related organisations like the Vietnam Coffee and Cocoa Association (VICOFA) could share the costs of training programmes for coffee farmers and companies of the processing step. Neumann Kaffee could try to initialise and lobby such an eco-efficiency programme. To date, Neumann has been involved in various projects that aim at increasing eco-efficiency in the supply chain. Most of these projects have been co-funded externally and supported by consultancy services including E.D.E. Consulting owned by the Neumann Foundation. Co-operative arrangements of Neumann and competing Vietnamese coffee exporters to improve the supply chain are not recorded.

The findings above are in line with the results of a comprehensive analysis of sustainable cotton supply chains. Goldbach et al. (2003) observed that the initial phase of environmental and sustainability supply chain management is characterised by cooperative or even hierarchical arrangements, while at later stages, market arrangements gain importance. Furthermore, they conclude that environmental supply chain management cannot be viewed as a technical matter only. It is rather an inter-organisational concept (Goldbach et al. 2003). It implies a 'change from managing supply chains based on serial dependence and power to recognising and managing the reciprocal dependence' (Cullen et al. 1999:31).

5 Conclusions

Neumann is one of many actors in the Vietnamese coffee industry and supply chain. Neumann's own business, the refinement and export of green Robusta coffee beans, is not causing huge environmental impacts. EMA has been used to confirm this, but it has also ascertained the financial relevance of even small raw material losses like dust and weight loss due to evaporation.

In contrast to the rather low environmental importance of its refinement and export operations, the supply chain in which Neumann operates is exposed to substantial environmental concerns. Using LCA information in the context of EMA has helped to identify those steps within the coffee supply chain that have highest environmental impacts and highest options for environmental improvement measures. Cultivation and consumption are the most important steps from an environmental perspective. Some of the environmental concerns in the supply chain have direct financial consequences. Energy inefficiencies and the overuse of fertiliser diminish the overall supply chain profits or lead to less competitive market prices. Neumann can get better understanding of these interdependencies by applying supply chain costing. Measures to increase the supply chain eco-efficiency need supply chain management efforts, in particular horizontal cooperation, for instance a joint initiative of coffee exporting companies to train farmers.

Besides Neumann, further actors within the supply chain can contribute to environmental and related financial improvements. Coffee consumers have an even bigger role in this than expected. By demanding alternative types of coffees like organic, fair trade or sustainable coffee, consumers influence the supply chain indirectly, in particular the cultivation step. But consumers can also directly reduce the environmental burdens of the coffee life cycle, for instance, by not making more coffee than is consumed, by using insulated coffee pots rather than leaving coffee on the percolator stove, by purchasing electricity from renewable sources or by substituting their electrical coffee machine.

This case study reveals the importance of environment-related supply chain information for corporate decision-making. EMA can make use of tools like LCA to satisfy this demand. In combination with concepts like supply chain costing this analysis leads to the identification and prioritisation of eco-efficiency improvements along the chain. In contrast to still growing niche market solutions like fair trade or organic coffee farming, supply chain eco-efficiency measures show a potential to directly enter the mass market of Vietnamese coffee production.

References

Atkinson AA, Kaplan RS, Matsumura EM and Young SM (2007) *Management Accounting* (5th edition) Upper Saddle River, Prentice Hall

Bennett M, Bouma JJ and Wolters T (2002) *Environmental Management Accounting. Informational and Institutional Developments* Dordrecht, Kluwer Academic Publishers

Bennett M, Rikhardsson PM and Schaltegger S (2003) *Environmental Management Accounting: Purpose and Progress* Dordrecht, Kluwer Academic Publishers

Blowfield M (2004) Ethical supply chains in the cocoa, coffee and tea industries *Greener Management International* 43 15–24

Burritt RL (2005) Environmental risk management and environmental management accounting – developing linkages *in* Bennett M, Bouma JJ and Wolters T*Implementing Environmental Management Accounting: Status and Challenges* Dordrecht, Kluwer Academic Publishers 123–141

Burritt RL, Hahn T and Schaltegger S (2002) Towards a comprehensive framework for environmental management accounting: links between business actors and environmental management accounting tools *Australian Accounting Review* 12.2 39–50

Clay J (2004) *World Agriculture and the Environment. A Commodity-by-Commodity Guide to Impacts and Practices* Washington DC, Island Press

Cooper MC, Ellram LM, Gardner JT and Hanks AM (1997a) Meshing multiple alliances *Journal of Business Logistics* 18.1 67–87

Cooper MC, Lambert ML and Pagh JD (1997b) Supply chain management: more than a new name for logistics *International Journal of Logistics Management* 8.1 1–14

Cullen J, Berry AJ, Seal W, Dunlop A, Ahmed M and Marson J (1999) Interfirm supply chains – the contribution of management accounting *Management Accounting* 77.6 30–32

Diers A, Langowski HC, Pannkoke K and Hop R (1999) *Produkt-Ökobilanz Vacuumverpackter Röstkaffee* Bayreuth, Eco-Informa Press

Doan T, Sturm A and von Enden J (2003) *First Environmental Report of Tan Lam Company* Huóng Hóa, Tan Lam Company

Dyllick T and Schaltegger S (2001) Nachhaltigkeitsmanagement mit einer Sustainability Balanced Scorecard *Umweltwirtschaftsforum* 9.4 68–73

E.D.E. Consulting for Coffee (2003) *Project Results from Dak Lak Area* Hanoi, E.D.E. Consulting for Coffee

Flexnews – Business News for the Food Industry (2007) Vietnam's coffee sales soar, dryness hits some areas, *Flexnews – Business News for the Food Industry* 26th March 2007 [online] [cited 2 April 2007] Available from Internet URL <http://www.flex-news-food.com/console/PageViewer.aspx?page=7959>

Figge F, Hahn T, Schaltegger S and Wagner M (2003) The sustainability balanced scorecard as a framework to link environmental management accounting with strategic management *in* Bennett M, Rikhardsson PM and Schaltegger S Environmental Management Accounting: Purpose and Progress Dordrecht, Kluwer Academic Publishers 17–40

Goldbach M, Seuring S and Back S (2003) Co-ordinating sustainable cotton chains for the mass market: the case of the German mail-order business OTTO *Greener Management International* 43 65–78

Guinée JB (2002) *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards* Dordrecht, Kluwer Academic Publishers

Hansen DR and Mowen MM (2006) *Managerial Accounting* (8th edition) Mason, South-Western

Herzig C, Viere T, Burritt RL and Schaltegger S (2006) Understanding and supporting management decision-making: South East Asian case studies on environmental management accounting in Schaltegger S, Bennett M and Burritt RL *Sustainability Accounting and Reporting* Dordrecht, Springer 491–507

Horngren CT, Sundem GL, Stratton WO, Burgstahler, D and Schatzberg J (2008) *Introduction to Management Accounting* (14th edition) Upper Saddle River, Prentice Hall

Hunkeler D, Lichtenvort K and Rebitzer G (2008) *Environmental Life Cycle Costing* Boca Raton, CRC Press

ICO – International Coffee Organization (2001) *Environmental Issues Relating to the Coffee Chain within a Context of Trade Liberalization, through a Life-Cycle Approach* London, ICO

IFAC – International Federation of Accountants (2005) *International Guidance Document Environmental Management Accounting* New York, IFAC

InWEnt Capacity Building International (2008) *EMA-SEA Program – Environmental Management Accounting for South-East Asia* [online] [cited 1 December 2008] Available from Internet URL <http://gc21.inwent.org/EMAportal>

Johnston J (2001) Bountiful harvests of despair: Vietnam and the global coffee crisis *TED Case Studies* 12.1 [online] [cited 2 April 2007] Available from Internet URL <http://www.american.edu/TED/class/all.htm#Jan2002>

LaLonde BJ and Pohlen TL (1996) Issues in supply chain costing *The International Journal of Logistics Management* 7.1 1–12

Lewin B, Giovannucci D and Varangis P (2004) *Coffee Markets – New Paradigms in Global Supply and Demand* Washington DC, World Bank

Neumann Kaffee Gruppe (2008) *Neumann Kaffee Gruppe* [online] [cited 11 December 2008] Available from Internet URL <http://www.nkg.net>

People's Daily Online (2006) Vietnam coffee industry still ailing *People's Daily Online* 9th May 2006 [online] [cited 2 April 2007] Available from Internet URL <http://english.peopledaily.com.cn/200605/09/eng20060509_264116.html>

Ponte S (2004) *Standards and Sustainability in the Coffee Sector – A Global Value Chain Approach* Winnipeg, IISD [online] [cited 2 April 2007] Available from Internet URL <http://www.iisd.org/pdf/2004/sci_coffee_standards.pdf>

Rikhardsson PM, Bennett M, Bouma JJ and Schaltegger S (2005) *Implementing Environmental Management Accounting: Status and Challenges* Dordrecht, Springer

Salomone R (2003) Life cycle assessment applied to coffee production: investigating environmental impacts to aid decision-making for improvements at company level *Food, Agriculture and Environment* 1.2 295–300

Schaltegger S, Bennett M and Burritt RL (2006) *Sustainability Accounting and Reporting* Dordrecht, Springer

Schaltegger S and Burritt RL (2000) *Contemporary Environmental Accounting: Issues, Concepts and Practice* Sheffield, Greenleaf

Seuring S (2004) Industrial ecology, life cycles, supply chains: differences and interrelations *Business Strategy and the Environment* 13.5 306–319

Williamson O (1975) *Markets and Hierarchies: Analysis and Antitrust Implications* New York, The Free Press

Williamson O (1985) *The Economic Institutions of Capitalism* New York, The Free Press

Chapter 3
Motivations Behind Sustainable Purchasing

Gyöngyi Vörösmarty, Imre Dobos, and Tünde Tátrai

Abstract Sustainability issues in purchasing are receiving greater attention. Literature is rapidly growing, with several research programmes being initiated to investigate the topic. This study presents the results of a research project which aims to reveal and structure the motivating forces leading companies to make efforts in sustainability purchasing and the means used to attain achievements in some fields of sustainability. Results presented in the literature are scattered in terms of the fields of sustainability: most of the studies focus only on green or corporate social responsibility issues and there is a lack of exploratory models. Sustainability in purchasing is addressed in a comprehensive way including green, social responsibility and corporate growth issues. After presenting the results of a literature review, theoretical development was undertaken to create a framework in which it is possible to describe the means of sustainability applied and the motivating forces behind them. This framework serves as the basis for an empirical investigation among Hungarian companies. Empirical results confirm the usefulness of the theoretical framework: the number and the characteristics of sustainability activities were determined by the particular types of motivation – to avoid negative effects, to achieve compliance with expectations and to attain positive effects.

Keywords Purchasing • Sustainable development • Environmental management • Corporate social responsibility

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1 Introduction

Literature on sustainability is rapidly growing, since widespread research activities have been carried out in recent years to investigate related management practices and to build models to structure knowledge acquired. This chapter focuses on a specific field of management by outlining sustainability issues in purchasing and supply chain management. It points out that companies are also customers but the way they carry out their buying activity is quite different from the way final consumers purchase their products. In any economy, purchasing by companies represents substantial buying power, and is concentrated in far fewer hands than in consumer markets. As a consequence, a relatively small number of companies are capable of motivating a wide range of suppliers and this could promote the spread of sustainable practices. The aim is to investigate:

- What motivates purchasing to be more sustainable, and
- How motivation factors relate to applied sustainability means.

This chapter is organised as follows. The literature review in Sect. 2 is followed by Sect. 3 which identifies and groups drivers and means of sustainable purchasing management; Sect. 4 considers the motivations for sustainable procurement and suggests a research framework. In Sect. 5, the methodology of the study is presented. Section 6 outlines the findings of the study. Finally, Sect. 7 outlines the conclusions and attention is drawn to limitations of the research and future research directions.

2 Understanding of Sustainable Purchasing in the Literature

Purchasing has increasingly assumed a pivotal strategic role and has been subjected to theoretical and empirical scrutiny (Chen et al. 2004, Ellram et al. 2002). However, until recently, most purchasing drivers have been identified as being value-for-money factors such as price, cost, quality performance and other issues in procurement decision making which have historically been regarded as contributing directly to profitability. As consideration and awareness of the notion of sustainability become widespread, there is an increasing need to find ways of managing the scope and range of decision-making variables.

Much American and European research has been published on sustainability issues in purchasing. Many research projects have been completed in this field; most focus on a singular aspect of the topic and the concept of sustainable purchasing is understood differently. Sustainable purchasing integrates long-term strategic, environmental and social issues. It is thus part of the sustainability concept that purchasing should support the steady growth and sustainable development of the firm. In this understanding the role of purchasing is twofold: to ensure a reliable supply of the goods and services required over both the short and long term, and ensure efficiency of operations (Young and Kielkiewicz-Young 2001). There exists another group of authors whose work is related to another element of the sustainability concept: environmental issues. Their investigations cover topics such as green purchasing strategy (Azzone et al. 1997, Min and Galle 2001) or how to make purchasing tools greener (Noci 1997, Schlegelmilch et al. 1996, Vachon and Klassen 2006). The third strand in the literature highlights social responsibility issues in purchasing (Boyd et al. 2007, Carter 2004, 2005, Drumwright 1994, Malomi and Brown 2006). The above-mentioned literature is closely related in content to the general literature on sustainability although, since the authors focus on individual elements of the sustainability concept, the results are hard to compare.

The research aim was to build a comprehensive approach to unite the three elements of long-term development and competitiveness, environmental concerns and social aspects. The following literature review first describes the means of sustainable purchasing and then the drivers or motivations for sustainability management. The research framework was prepared based upon these results.

3 Means of Sustainable Purchasing – Literature Review and Theory Building

The broad understanding of sustainable purchasing covers a wide range of activities and knowledge within organisations. As the purchasing and supply management literature rarely connects the three elements of the broad definition of sustainable purchasing, the description of means in relevant literature is not comprehensive.

3.1 Corporate Growth and Competitiveness

The literature on corporate growth is substantial (Dyllick and Hockerts 2002, Park and Jang 2010, Reinhardt 2000). Studies have an overall business perspective and typically do not address functional issues (marketing, production, purchasing). However, growing recognition of the purchasing function has resulted in a substantial number of publications. These studies put an increased focus on the issue of how purchasing adds strategic value and contributes to corporate success. A wide-ranging review of documented sources was undertaken by Zheng et al. (2007), leading to the identification of 42 core studies on the topic. Most of these 42 studies investigate the issue of the strategic relevance of purchasing, although only a few directly address the issue of the role of purchasing in promoting the long-term competitiveness of an organisation. As a consequence, the role of strategic purchasing is well documented: it is to build cross-functional, inter-organisational relationships. As Chen et al. (2004) explain in their research model, strategic purchasing can engender competitive advantage by enabling firms to (a) foster close working relationships with a limited number of suppliers; (b) promote open communication among supply-chain partners and (c) develop long-term strategic relationship orientation to achieve mutual gains.

3.2 Green Purchasing

In the last few decades, green movements, institutions and government regulations (and supporting initiatives) have caused companies to improve their environmental performance. To respond to this growing concern for green issues, firms have carried out a great number of environmental programmes ranging from reducing emissions in air to the introduction of eco-auditing frameworks.

The increased responsibilities of purchasing in this context are well documented in the literature, as a number of investigations have been carried out with the aim of obtaining an overall picture of green purchasing strategies (Holt 2004, Min and Galle 1997), connecting corporate competitiveness of the firm with green purchasing activities (Carter et al. 2000, Mebrau 2001) and cross-national comparisons (Arnold et al. 1999, Carter et al. 1998). The results published in these articles are based on empirical investigation, which requires evaluation and description of green purchasing. Min and Galle (1997) provide the most comprehensive model, in which they develop a classification of green purchasing activities: source reduction (recycling, reuse, source changes and control) and waste elimination (biodegrading, non-toxic incineration, scrapping and dumping). However this model does not follow the latest development of the purchasing and supply profession, e.g. supplier development.

In developing a research framework, it was proposed that the role of purchasing in environmental context is threefold:

First, as purchasing and supply management is responsible for the obtaining of a wider range of products and services, *purchasing is thus involved as a contributor to environmental projects* and applied purchasing tools (specification preparation, supplier evaluation, etc.). For example when purchasing equipment, as part of a purchasing decision, it may be checked to see how much energy the equipment consumes. So the environmental attributes of the product to be purchased receive emphasis.

Second, purchasing is recognised as *a process itself*, which may have green attributes. For example, the purchasing department uses recycled paper to print contracts.

Third, purchasing – as a boundary spanning function – has a role when *communication with the potential supply base* is highlighted. The purchasing process may involve (as part of the supplier evaluation) not just product attributes, e.g. which parts of the product can be recycled, but also the environmental aspects of the operations of the supplier, e.g. air pollution created during the manufacturing process.

3.3 Social Responsibility in Purchasing and Supply Management

Purchasing managers span the boundary between the firm's internal functions and its external stakeholders, including suppliers and third parties. So purchasing is advantageously positioned to affect firms' involvement in socially responsible activities. Literature in the field of purchasing and supply management has started to investigate issues related to social responsibility. However, only a few of these investigations are based on a comprehensive understanding of Purchasing Social Responsibility (PSR); most of them focus on a single element, e.g. ethical issues in purchasing.

Boyd et al. (2007) lists three elements: social labels, socially responsible investments and codes of conduct. Several further pieces of research (Koplin et al. 2007) were based upon Carter and Jennings' (2000) model, which is based upon empirical investigations of US organisations, and which identified six categories – namely environmental management, safety, diversity, human rights, ethics, community and philanthropic activities. This model of Carter and Jennings is comprehensive and has been internationally tested and verified to be an appropriate base for further theoretical and empirical investigation.

3.4 A Research Framework for Identifying the Applied Means of Sustainable Purchasing

As it may be seen, literature on the content of sustainable purchasing is quite complex. In the case of economic development and PSR it was easy to find appropriate approaches and suitable classifications. In case of social responsibility the model of Carter and Jennings (2000) mentioned above has been adapted with a minor modification. The case of green purchasing required some theory building, since the existing models do not support the measurement of corporate involvement in green purchasing activities.

4 Motivation for Sustainable Purchasing, Literature Review and Theory Building

The question of why organisations choose to adopt socially responsible or green practices has become an increasingly important topic in research papers. As in the case of the fields of sustainable purchasing, the research aim also required identifying a structured model of motivation.

4.1 Literature on Motivations for Sustainable Procurement

A range of drivers and barriers is identified in the literature. However, the investigations have a different focus (as it was mentioned, the studies typically concern green purchasing or corporate social responsibility (CSR) in purchasing, and just a few refer to sustainability issues in a comprehensive way), the identified elements are very similar. A significant body of research indicates that legislation and public policy are major motivations for companies' sustainability efforts (Carter and Dresner 2001, Min and Galle 2001, Walton et al. 1998). Customer expectations, fierce competition and other market-related effects are also found to be important in driving sustainability (Handfield and Baumer 2006). High importance is given to cooperation with stakeholders and to compliance with their expectations (Reeve and Steinhausen 2007, Vachon and Klassen 2006). It is also highlighted that the role of individuals might be of importance (Drumwright 1994).

In addressing the question of motivation, researchers have put forward a variety of models and concepts on how to structure the motivating forces. Walker et al. (2008) undertook a large-scale literature review and, based on these results, they identify the drivers of green supply chain management according to their source as being either internal (organisation-related) drivers or external drivers (regulation, customers, competitors, society and suppliers). The model is validated by case studies from the public and private sector. Another study aiming to provide a structured answer to the question of why organisations choose socially responsible practices was prepared by Worthington et al. (2008). Based on information gathered from literature and case studies of US and UK firms, they analyse what drives the sample organisations to engage in developing supplier diversity initiatives. The research framework of this investigation is also based upon literature results. They use the general (not specifically purchasing-related) literature of sustainability to build their model. They identify four influencing factors: legislation/public policy, economic opportunities, stakeholder expectations and ethical influences. Both author's models of influencing forces are comprehensive, relevant and provide a logical structure of identified factors. However both of them were willing to describe organisations' practice in a structured way and be able to identify similarities and differences of samples (private and public sector and UK and US firms). Unfortunately literature does not provide such a model, which helps to explain how the motivation forces drive the actions of purchasing experts to develop and use sustainable means and solutions. To investigate this relationship, such a model is required, which provides a good ground to investigate the motivation forces.

4.2 Research Model for Motivation for Sustainable Purchasing

The investigation of the relationship between sustainability means and motivation required a structured model of motivations. Three groups of motivating forces were identified: the avoidance of negative effects, compliance with expectations, and achievement of positive goals.

Avoidance of negative effects may motivate procurement to be 'more sustainable' in many ways. Government legislation may include elements that will be sanctioned if they are not complied with. Negative publicity resulting in loss of sales is another example. In these cases the aim is to somehow avoid the negative reactions of stakeholders. These motivations have the effect that companies (managers) act only if they feel endangered.

Compliance with expectations means that there is an initiative for the purchasing function or for the organisation which must be satisfied. Here, the means are given; an initiative of the owners such as developing a code of conduct but may also stem from competition e.g. other competitors already have ISO 14000 certification.

Positive achievements mean that acts (or form of activities) are carried out as activities supporting sustainability, but companies and their stakeholders realise positive benefits. This positive benefit is often linked to the financial performance of the firms e.g. good public relations in the context of increasing sales.

Purchasing and supply function is motivated in all three ways. But the manner in which they motivate managers is significantly different:

- In cases of avoidance of negative effects, managers will only act if they feel the risk. This may provoke creative solutions but it is not likely that such a response will create more enthusiasm than required to avoid the negative effect.
- Compliance with expectations is a bit similar; only the solution is more or less given. It does not require further action beyond that necessitated.
- Positive motivation is that which indicates creative solutions and long-term commitment to achievements.

These motivations are present in organisations simultaneously.

5 Research Methods

In an effort to shed light on the relationship of motivation and means of sustainability specified earlier, an explorative study was conducted using interviews in 13 organisations. Of these 13 organisations, three were public and ten were private organisations. The private organisations (except for two) are owned by multinational firms. Four out of the ten private firms operate in the manufacturing sector (pharmaceutical, chemical, beverages) while six operate in the service sector (bank, telecommunication, hotel chain, restaurant chain). Companies were ensured anonymity to encourage openness of responses. All the organisations operate in Hungary. Organisations were selected that have corporate initiatives in the field of environmental policy or CSR, but preferably both of these.

The interview protocol was developed on the basis of the literature review and research framework presented above. Semi-structured interviews were conducted with at least one manager in each organisation. Participants were senior purchasing managers. Secondary data were collected (such as environmental policy, codes of conduct, etc.).

The interview took the following form:

- Identification of company organisational background
- Identification of participant's understanding of sustainability

- Examination of objectives and responsibilities of the purchasing organisation
- Questions regarding green purchasing
- Elicitation of information on the topic of social responsibility in purchasing e.g. involvement in community activities, safety issues, diversity, legal issues, human rights and ethics, etc.

After completing the interviews, two experts identified activities undertaken by the purchasing organisation and validated the motivation aspects (drivers) for the applied activity.

6 Case Results

To investigate the motivating forces behind sustainable purchasing and the activities and the relationships around them, the research framework described above was employed. As mentioned in the research methodology section, two experts validated each interview by identifying the activities mentioned in the interview, classifying the motivation 'type' for the activity and the source of motivation. In total, 90 activities were identified arising from 13 interviews. The following results are based on the statistical analysis of these 90 activities. The research framework described above has been used to structure the analysis. First the three elements of sustainability were reviewed – corporate growth and competitiveness, environmental concerns and social aspects – then the types of motivation were identified (avoidance of negative effects, compliance to expectations, positive achievements) and finally the connection between the type of motivation and elements of sustainability was described.

6.1 Green, CSR, and Growth Means of Purchasing

As the investigation was built on a comprehensive approach, the interview covered the three elements of sustainability: corporate growth, environmental aspects and social responsibility.

6.1.1 Corporate Growth and Competitiveness

The interview responses suggest that the most important expectations purchasing should encompass to takes two forms. First is supply reliability, e.g. avoiding interruptions in production supply, etc., while the other is to meet expected financial demands, e.g. costs, budget, earnings before interest, tax, depreciation and amortisation (EBITDA). (In theory, both can be connected to sustainable management although the interview results reveal that this seldom happens or just in certain projects. Performance indicators motivated the purchasing management to consider short-term optimisation, e.g. focus on the current year EBITDA effects only.

Only four interviews, all of them in private firms, were identified where activities to protect the environment were undertaken in order to achieve some cost reduction. Supply reliability in the long-run as an important factor of purchasing performance was mentioned only twice, mainly when the possibility of supply interruptions due were identified as a real risk. This implies that factors described in the literature were not identified as explicit goals.

6.1.2 Environmental Aspects

As part of the research framework, green issues in purchasing were analysed at three levels. In 13 interviews, 31 activities were identified. (An activity might belong to two levels.) The 31 identified activities reflected that the interviewed organisations pay attention to involving environmental concerns in the buying decision (18 activities, 11 interviews) and to make the purchasing process greener (16 activities, 10 interviews). However, the solutions mentioned do not vary between companies (typically being compliant with law, recycling of paper, re-collection of electronic garbage). The organisations interviewed pay much less attention to the processes of the supplier (six activities, four interviews). However, some creative ideas on this topic arose here, e.g. giving an environmental award to suppliers.

6.1.3 Social Responsibility

Six aspects were reviewed in the interviews: local communities, diversity, ethics, legal issues, safety and human rights. The interviews revealed a much more variable picture than was expected. The number of activities mentioned was relatively large, and more creative and unique solutions were found. The results were as follows (see Table 3.1).

The six aspects of social responsibility appeared divided into two groups: four aspects (local community, ethics, legal issues, safety) were mentioned almost the same number of times and two aspects (diversity, human rights) were covered less frequently. The same number of mentions within the two groups may be accidental; however the difference between the two groups is important. It is not possible to

Table 3.1 Activities according to social responsibility topics

	No. of activities according to the six topics	No. of interviews in which an activity topic was mentioned
Local communities	10	8
Diversity	4	4
Ethics	8	8
Legal issues	8	7
Human rights	4	4
Safety	8	8

manage diversity and human rights through purchasing means; however they are important issues to society. Because of the characteristics of the supply base they necessarily represent a challenge. The following examples describe the most common reasons for this. Minority groups (small firms, minority-owned businesses) are not represented on the supply markets, so it is neither possible to discriminate, nor to support them. The other example is that most of the supply base which is managed by the interviewed purchasing managers is located in the European Union or the United States, where child labour, as an example of a human rights issue, is strictly and effectively forbidden. Low-cost country suppliers, e.g. China and India, are managed or qualified by headquarters. Human rights and diversity are frequently raised in international literature on social responsibility as important issues; however the results suggest that this finding is only valid in a low-cost country context. However, results reveal that the contribution of purchasing to other fields of social responsibility is also important.

6.2 *Motivation Types*

The most frequent driver was ‘compliance’ (38 mentions), followed by ‘avoidance of negative affects’ (30); the least frequently mentioned driver was ‘positive achievements’ (22). To analyse these results, the source of motivation was identified (in certain cases more than one source was identified). The relationship between the type of motivation and the source of motivation is described in Fig. 3.1.

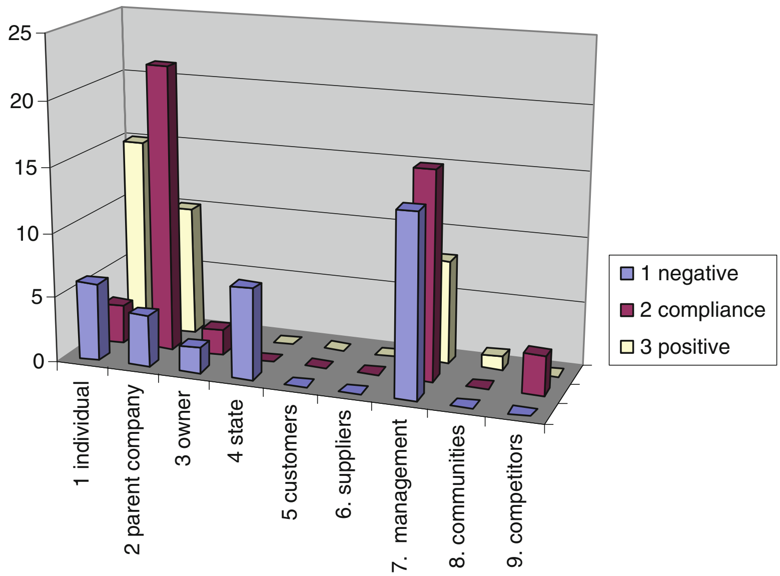

Fig. 3.1 Activities according to the type of motivation and the source of motivation

In most cases, motivation to act in a sustainable way originates from the parent company, higher management or from the individual. In the case of ‘avoidance of negative affects’ the role of management was the highest and government was a second major driving force (mainly due to environmental and safety regulations). In case of ‘compliance to expectations’ the parent company and higher management were the most frequent source of motivation. In the case of positive motivation, the role of the individual tended to be the strongest while the role of the parent company and management was relatively strong (data is distorted as positive motivations were ascribed to three firms only).

To sum up these findings, the purchasing managers (organisations) promoted sustainability either in those situations when the parent company and the management were determined to incorporate purchasing (and the supplier relationships) into the sustainability policy of the firm (the way to achieve it may be very different) or when the individual was strong enough to act on his or her own will and had taken the opportunity to promote sustainability. By analysing the role of potential stakeholders it is evident that purchasing managers try to satisfy the expectations of the parent company (they represent the owners) and the management. However, it was much less evident why so little motivation stems from other stakeholders of purchasing (customers, suppliers, local communities, etc.)

6.3 Relationship Between the Types of Motivation and Fields of Sustainability

Analysis of the activities of sustainable purchasing according to the fields of sustainability and type of motivation revealed the following results (see Table 3.2).

In the case of contribution to long-term corporate competitiveness and growth, avoidance of negative effects and compliance with expectations were the most typical drivers. The dominating motivation for greener purchasing was compliance with expectations; however, there were several examples for the other two types of motivations as well. In the case of social responsibility, the roles of the three types of motivations were more or less equal.

Table 3.2 Activities according to type of motivation and field of sustainability

	Development	Environment	Social responsibility	Total
Avoidance of negative effects	7	6	15	28
Compliance with expectations	7	17	14	38
Attaining positive effects	3	8	13	24
Total	17	31	42	

7 Conclusion and Implications for Further Research

The results described above indicate that the interviewed organisations undertake a number of sustainable purchasing initiatives. The motivational background for these initiatives provided explanations for the frequency of the use of certain sustainability-related activities. This provides support for the applicability of the research framework developed.

Summing up the results of the interviews, the following conclusions can be drawn:

1. In most of the cases the motivating force falls into the category of 'avoiding negative effects' or 'compliance with expectations'. Based upon the described research model this explains why companies have a few initiatives but do not do more and that the identified activities were routine and undertaken without much creativity.
2. Sustainable purchasing does not necessarily offer a public relations advantage. It is not possible to gain customers this way. On the other hand, organisations and their purchasing representatives consider conventional competitive priorities as a priority; as a consequence, companies did not even possess data on disadvantaged or minority suppliers.
3. The most colourful and creative activities were indicated in the field of social responsibility. This was partly due to the fact that it is a broad field. However, the role of positive motivation (here, the role of the personal motivation of purchasing staff) was most important.
4. Local sustainability-driven purchasing patterns and behaviour are missing and as a consequence, managers default to international norms which address global challenges (such as child labour) but do not deal with local problems.
5. While each organisation interviewed had an environmental and a CSR policy, the three public organisations focused mainly on arranging their purchasing process according to public procurement law and they hardly incorporated any elements of sustainability into their purchasing processes.

Some implications for further research have emerged. It would be of practical and theoretical interest to identify and develop locally based sustainability focused purchasing patterns. Industry background apparently influences sustainability practice, which is further worth investigating. Public and private organisations take different approaches. As these approaches are affected by government legislation comparison of such international approaches could raise useful information.

References

Arnold U, Cox A, Debruyne M, Iyogun P, Hendrick T, Liouville J and Vörösmarty Gy (1999) A multi-country study of strategic topics in purchasing and supply management Tempe, Centre for Advanced Purchasing Studies

Azzone G, Bertele U and Noci G (1997) At last we are creating environmental strategies which work *Long Range Planning* 30.4 562–571

Boyd ED, Spekman RoE, Kamauff JW and Wehane P (2007) Corporate social responsibility in global supply chains: A procedural justice perspective *Long Range Planning* 40.3 341–356

Carter CR (2004) Purchasing and Social Responsibility: A replication and extension *Journal of Supply Chain Management* 40.4 4–16

Carter CR (2005) Purchasing and social responsibility and firm performance, key mediating roles of organizational learning and supplier performance *International Journal of Physical Distribution & Logistics Management* 35.3 177–194

Carter CR and Dresner M (2001) Purchasing's role in environmental management: Cross-functional development of grounded theory *Journal of Supply Chain Management* 37.3 12–27

Carter CR and Jennings MM (2000) Purchasing's contribution to the socially responsible management of the supply chain US, Centre for Advanced Purchasing Studies

Carter CR, Ellram LM and Ready KJ (1998) Environmental purchasing: Benchmarking our German counterparts *International Journal of Purchasing and Materials Management* 34.4 28–38

Carter CR, Kale R and Grimm CM (2000) Environmental purchasing and firm performance: An empirical investigation *Transportation Research Part E: Logistics and Transportation Review* 36.3 219–228

Chen IJ, Paulraj A and Lado AA (2004) Strategic purchasing, supply management and firm performance *Journal of Operations Management* 22.5 505–523

Dyllick T and Hockerts K (2002) Beyond the business case for corporate sustainability *Business Strategy and the Environment* 11.2 130–141

Drumwright ME (1994) Socially responsible organisational buying: Environmental concern as a noneconomic buying criterion *Journal of Marketing* 58.3 1–19

Ellram LM, Zsidisin GA, Siferd SP and Stanley MJ (2002) The impact of purchasing and supply management activities on corporate success *Journal of Supply Chain Management* 38.1 4–17

Handfield RB and Baumer DL (2006) Managing conflict of interest issues in purchasing *The Journal of Supply Chain Management* 42.3 41–50

Holt D (2004) Managing the interface between suppliers and organizations for environmental responsibility – An exploration of current practices in the UK *Corporate Social- Responsibility and Management* 11.2 71–84

Koplin J, Seuring S and Masterharm M (2007) Incorporating sustainability into supply management in the automotive industry-the case of the Volkswagen AG *Journal of Cleaner Production* 15.11–12 1053–1062

Malomi MJ, Brown ME (2006) Corporate social responsibility in the supply chain: An application in the food industry *Journal of Business Ethics* 68.2 35–62

Mebrau D (2001) Environmental competitiveness "green" purchasing *International Trade Forum* 2 11–13

Min H and Galle WP (1997) Green purchasing strategies: Trends and implications *International Journal of Purchasing and Materials Management* 33.3 10–17

Min H and Galle WP (2001) Green purchasing practices of US firms *International Journal of Operations and Production Management* 21.9–10 1222–1238

Noci G (1997) Designing "green" vendor rating systems for the assessment of a supplier's environmental performance *European Journal of Purchasing and Supply Management* 3.2 103–114

Park K and Jang S (2010) Firm growth patterns: Examining the associations with firm size and internationalization *International Journal of Hospitality Management* 29.3 368–377

Reeve T and Steinhausen J (2007) Sustainable suppliers, sustainable markets *CMA Management* 81.2 30–33

Reinhardt F (2000) Sustainability and the firm *Interfaces* 30.3 26–41

Schlegelmilch BB, Bohlen GM and Diamantopoulos A (1996) The link between green purchasing decisions and measures of environmental consciousness *European Journal of Marketing* 30.5 35–55

Vachon RD and Klassen S (2006) Green project partnership in the supply chain: The case of package printing industry *Journal of Cleaner Production* 14.6–9 661–671

Walker H, Sisto L and McBain D (2008) Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors *Journal of Purchasing and Supply Management* 14.1 69–85

Walton S, Handfield RB and Melnyk SA (1998) The green supply chain: Integrating suppliers into the environmental management process *International Journal of Purchasing and Materials Management* 34.2 2–11

Worthington I, Ram M, Boyal H and Shah M (2008) Researching the drivers of socially responsible purchasing: A cross-national study of supplier diversity initiatives *Journal of Business Ethics* 79.3 319–331

Young A and Kielkiewicz-Young A (2001) Sustainable supply network management *Corporate Environmental Strategy* 8.3 260–268

Zheng J, Knight L, Harland C, Humby S and James K (2007) An analyses of research into the future of purchasing and supply management *Journal of Purchasing and Supply Management* 13.1 69–83

Chapter 4
An Input–Output Technological Model of Life Cycle Costing: Computational Aspects and Implementation Issues in a Generalised Supply Chain Perspective

Ettore Settanni, Giuseppe Tassielli, and Bruno Notarnicola

Abstract Material and cost flows play an important role within manufacturing systems in setting the structural interdependences among a supply chain of production processes. Environmentally-extended input–output analysis provides a computational structure that takes these interdependences into account. This is interesting for many applications within supply chain analysis and business processes analysis, especially as far as cost accounting is concerned. This chapter addresses the emerging issue of incorporating costs into life cycle assessment as a premise to outline a concept of life cycle costing based on an input–output technological model. This model is common to both physical accounting and cost accounting. It allows product costing and resource planning to be carried out while taking into account issues concerning inter-organisational cost management, multi-product systems, closed-loop recycling, pollution abatement processes, and the production and disposal of waste. Such a framework can also be employed in order to evaluate what effect different design solutions are likely to have on both the material flows, and even the associated whole-of-life costs.

Keywords Life cycle costing • Enterprise input–output accounting • Supply chain • Environmental costs • Life cycle assessment

1 Background and Motivations

It is no longer unusual to find costs and environmental aspects, such as material and energy flows simultaneously addressed within the analysis of manufacturing systems. Both dimensions have been widely demonstrated to be relevant for decision-making at the corporate level, and some degree of *integration* between them has been

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recognised as desirable to achieve (Burritt et al. 2002, Schaltegger and Burritt 2000). More specifically, current trends show that environmental cost accounting, as a sub-discipline of environmental management accounting (EMA), increasingly requires shifting its emphasis from quantifying the additional costs of end-of-pipe environmental protection to assessing the repercussions of cleaner and more efficient integrated technologies on costs; at the same time, it requires extending the analysis to include downstream and upstream process stages in addition to the actual production process (Schaltegger and Wagner 2005). Well-known methods already exist that are relevant to both litera ture and business practice, with the aim of integrating physical and cost accounting, though to a different extent: environmental life cycle costing (Hunkeler et al. 2008), material flow cost accounting (Jasch 2009, IFAC 2005, Wagner and Enzler 2006, BMU and UBA 2003, Strobel and Redman 2002), resource efficiency analysis (Busch et al. 2006, Orbach and Liedtke 2002), material flow networks (Laurin et al. 2006, Schmidt 2005, Schmidt and Schwegler 2008), physical system theory (Sushil 1992) and enterprise input–output balances (Gale 2006, Jasch 2003 Mueller-Wenk 1978 Ullmann 1976). Moreover, supply chain management (SCM) and costing take into account also the repercussions that the actual structure of relationships among partners along a supply chain may have on both product costs and environmental aspects (Geffen and Rothenberg 2000, Seuring 2003, 2001).

It can be argued, however, that the computational aspects of costing methods are seldom made explicit and formalised in details, unlike the analytical environmental management tools, or the environmental balances they are combined with. Whatever approach is chosen, the computational aspects remain to a great extent a matter of specific computer-based applications. The discussion about integrating the different fields of EMA and appropriate EMA instruments concerns either the linkages between enterprise resource planning (ERP) and environmental management information systems (EMIS) or the implementation of applications that go beyond the ERP while supporting EMA instruments (Funk et al. 2009, Möller and Schaltegger 2005, Möller et al. 2006). While this aspect is remarkably useful to put EMA into everyday business practice, it also implies that the meaningful information about the relevant cost categories are to be gathered and managed relying on the involved actors' information systems, which are expected to be *already* in place. Unfortunately, such an assumption is seldom verified. In the case of Italian small- and medium-sized enterprises (SMEs), the availability of advanced business information systems like activity-based costing (ABC) cannot be as yet taken for granted (Bhimani et al. 2007, Carenzo and Turolla 2009) – let alone EMIS (Pilisi and Venturelli 2003, Venturelli and Pilisi 2003), life cycle costing (LCC) (Cinquini et al. 2008) and combinations thereof. Of course, the situation of European SMEs cannot be generalised – examples of somewhat different situations can be found in Wendish and Heupel (2005), Heupel and Wendish (2003). Yet, Bartolomeo et al. (2000) found that EMA activity in Europe seldom represents a systematic and comprehensive implementation and, more importantly, there is often no correlation across companies between their methods of production, the types of product, and their approaches to EMA.

In this chapter an effort will be made, therefore, to outline a generalised mathematical procedure that uses matrix algebra to model the structural elements of manufacturing systems, thus providing a basis for integrating production planning and costing methods that focus on business processes, such as LCC, process costing and ABC (Boons 1998). The proposed approach is bottom-up. It describes how the material flows, as well as other operational parameters characterising the stages of an operation chain including manufacturing, delivery, consumption and pollution abatement activities, can *actually* be recognised as cost drivers and managed at the firm and the supply chain (SC) levels. In this perspective, the point should not be only to accurately establish an ever-increasing relationship among the environmentally-induced costs and the product costs (Kumaran et al. 2003) but also to perform better management accounting by doing EMA (Jasch 2003).

For the sake of transparency, the proposed procedure can be implemented by using common spreadsheets, providing especially SMEs with a tool that is meant for *diagnosis*. Given a quantitative description of the production techniques adopted, this procedure is expected to clarify how *current* and *prospective* production choices affect process and product costs through the consumption of resources and the environmental aspects associated with the operation chain. To carry out such diagnosis may prove useful to a firm before committing itself to a specific information system.

The proposed computational procedure goes beyond, at least theoretically, the black box view of the firm from a cross-departmental and cross-company perspective by means of the identification and exploitation of both internal and external linkages along the industrial value chain. For this purpose, LCC has been chosen as a reference tool while outlining the procedure. The reasons for this choice are mainly based on possible developments that can still be achieved with reference to LCC, rather than on its well-established background. LCC still has an unexploited potential as a *costing* method that reflects the technology of the operations, showing conceptual similarities with supply and value chain management. Moreover, the literature has not yet deeply investigated the extent to which LCC could actually share a formalised computational structure based on linear algebra similar to life cycle assessment (LCA) and SCM. LCC would mostly benefit from the development of a formalised computational structure. Particular emphasis will be placed on what analytical features such computational structure should have in order to serve adequately the cost accounting purposes of one or more of the actors involved. The environmental extensions of the model which are necessary to assign the costs of end-of-pipe treatments and to take into account closed-loop recycling will be also investigated.

As a premise, in Sect. 4.2 attention will be paid to the meaning of LCC and not only as a discounted cash flow-based asset management tool. Considering LCC as a cost accounting tool, instead, it will be claimed that environmentally extended input–output analysis (IOA) can provide analytical support in its formulation. The proposed input–output-based computational structure of LCC will be then outlined in Sects. 4.3 through 4.5, focussing on the theoretical foundations. A simple numerical example will be provided that serves for illustrative purposes. Section 4.6 will draw some conclusions and future research issues.

2 An Overview of Approaches to Life Cycle Costing

The reasons for choosing LCC as a reference method are mainly based on possible developments that could be achieved in the field of LCC rather than on its well-established background. In this section, a brief overview of different approaches to and definitions of LCC will be provided in order to highlight those methodological issues that call for the outline of its formal computational structure.

2.1 The Scope of LCC

LCC has a long tradition as a discounted cash flow analysis supporting the procurement process of some durable asset, focussed on *ad hoc* information concerning that asset, especially the post-purchase costs that are expected to be incurred by the owner (Bennett and James 2000a, Dhillon 1989, Ellram 1995, Hutton and Wilkie 1980, Woodward 1997). Based on such a ‘user’ (or investor) perspective, the chains of manufacturing activities preceding and following the use stage are ignored, being summarised in the purchase price (the disposal fees). LCC as a cash flow analysis applies mainly to durable goods (Asiedu and Gu 1998, Durairaj et al. 2002, Utne 2009). Regarding nondurable products, LCC is in fact the assessment of the prospective investments in plants producing such products. This is especially the case for electric energy (DePaoli and Lorenzoni 1999, Swift-Hook 1997) and food (Clark 1997) but also for services such as effluent treatments (Tsagarakis et al. 2003). This further narrows the scope of LCC which cannot be applied to the analysis of manufacturing s ystems unless they are seen as prospective investments (Westkämper et al. 1998), thus preventing LCC from analysing in a consistent way the operation of existing technologies.

The concept of LCC changes, however, as the underlying concept of life cycle does, thus reflecting also the viewpoints of the producer – understood as either the production or the marketing function, the supply chain, the product itself and even society (Emblemsvåg 2003, James 2003, Shield and Young 1991). It can be argued that the key feature of LCC is simply that it widens the scope of product cost analysis in order to recognise opportunities for affecting – possibly eliminating – future costs beforehand, beyond the company gates and/or over an extended time-span. As Lindholm and Suomala (2005) point out, the essential thing in LCC is to comprehend the interaction of the cost items that cumulate among the relevant stakeholders during the different life cycle stages of a product.

If LCC is understood as a costing method, instead of just a cash flow analysis, it can be used in a producer perspective and its scope will not be narrowed *a priori*. Within the producer LCC (Artto 1994, Shield and Young 1991) the chain of manufacturing activities not only the use phase is relevant and so it is necessary to identify clearly a relationship that links the alternatives involving product architecture, the manufacturing processes, the use and end-of-life scenarios (Asiedu and Gu 1998, Bras and Emblemsvåg 1995, Fabrycky and Blanchard 1991). The cost assignment mechanism should be explicitly addressed together with specific data concerning the business processes involved, in the relevant life cycle phases (Dimache et al. 2007, Fabrycky and Blanchard 1991, Fixson 2004, Hansen and Mowen 2003).

Unfortunately, cost assignment mechanisms are neither questioned nor performed explicitly within LCC even if a producer perspective is adopted. This is for several reasons. Firstly, the distinction between terms such as costs, cash flows and expenses is often not clear-cut. Secondly, LCC does not replace traditional detailed cost or management accounting practice, but instead relies on it (Hunkeler et al. 2008). The availability of adequate corporate information systems is among the crucial factors for the successful implementation of LCC (Dunk 2004). Thirdly, raw cost estimations have been justified due to the comparative nature of LCC (Rebitzer et al. 2003). Cost data may be expressed therefore as figures of different quality collected in various ways, without providing details as to the calculations (see, for example Bovea and Vidal 2004, Ciroth 2009, Gess and Cohan 1995, Janz et al. 2006, Krozer 2008, Tapia et al. 2008). Finally, prices are often seen as a good proxy for costs, the latter being confidential and sensitive data (Ellram and Fetzinger 1997, Hunkeler et al. 2008, Koleian and Kar 2003, Roes et al. 2007). It clearly emerges that the producer LCC cannot be adequately used for expanding cost planning and control if the above points occur. It suffers the same limitation of traditional costing approaches insofar as the costs of environmental management are arbitrarily assigned to cost objects without reflecting causal relationships which are physical in nature (Epstein and Wisner 2002).

A new perspective on LCC reveals its unexploited potential as a method that closely links LCC to cost accounting and adequately reflects the technology of the operations. According to the concept called activity-based LCC (Emblemsvåg 2001, 2003, Rodriguez and Emblemsvåg 2007), if the main idea of traditional LCC, not the methods is utilised in cost management the latter will change from hindsight to dealing with costs even before they are incurred. In this way, the horizon of the cost management efforts and performance measures is expanded to the relevant parts of the life cycle where value is created. Following this approach, a definition of LCC which is of interest here, can be formulated:

> LCC is a process-orientated engineering *and* management tool, namely a *costing* method – neither just a cash flow nor an expense model. It allows the estimation of future costs directing attention towards their causes, both *inside* and outside the organisation with the aim of eliminating them before being incurred and thereby reducing expected risks. Being process-orientated, unlike *ad-hoc* analysis, it can address the entire cost structure of the company as well as any other cost object, such as products and processes, at the same time. It can be both hindsight and foresight orientated, and it does not focus exclusively on cash flows since they are not appropriate for keeping track of resource consumption.

Such meaning of LCC directs attention towards the causes of future costs, both inside and outside the organisation(s), to include the important life cycle stages where value is created. Unlike other definitions and mere combinations with physical accounting tools, the definition warrants the identification and exploitation of both internal and external linkages along the industrial value chain to help management make more informed decisions.

2.2 The Concept of Life Cycle Underlying LCC

Rather than focussing on life cycle as the time span a product exists, here it is understood as a chain of operations which is relevant from a producer's perspective or a supply chain perspective in order to identify opportunities for cost reductions within and beyond the boundaries of the individual company. As Seuring (2003) correctly remarks, the life cycle of a product is not an entity in itself which is outside the control of the individual companies taking part in it. Here it should be clear, who will make decisions on the individual steps in the production process or aims to fulfil customer demands. From a producer perspective, the life cycle includes both the manufacturing and post-purchase customer support and product disposal activities which should be conveniently considered by the producer at the earlier product design phase. The supply chain perspective usually covers a larger part of the chain, starting from pre-production to the end user. Although it is somet imes identified with the 'product' perspective, the latter implies that the life cycle spans across *all* the physical stages a manufactured product undergoes, from raw material extraction to its final disposal, *regardless of the actors involved*. Such a perspective is commonly adopted in LCA to carry out environmental assessment. Yet, it is argued that the product perspective is less appropriate for LCC than the supply chain one.

To implement LCC from a 'product' perspective means analysing the firm similar to value chain costing (Shank and Govindarajan 1996) and open book accounting (Kajüter 2002, Kajüter and Kumala 2005). The holistic approach of the value chain concept can be viewed in principle as the LCA approach in management accounting (James et al. 2002). Just as in LCA, however, this might lead to overlooking the individual problems that have to be tackled by a certain actor or firm (see for example Nguyen et al. 2008, Zhang et al. 2003). SCM may prove to be less different *in principle* from LCC than LCA especially if it takes a longer part of the chain into account, for example when environmental aspects are at stake (Beamon 1999, Seuring and Müller 2008). The same physical backbone and conceptual basis of LCA, can be found also in the concept of integrated chain management (ICM). ICM, however, pays attention not only to the flow of materials and information, but also to the actor network involved, just as SCM – though the latter particularly emph asises the operational and managerial aspects (Seuring 2004a,b). To adopt a supply chain perspective in LCC means integrating the product, relationship and cost dimensions (Seuring 2002, 2003). As a consequence, the system boundaries of LCC analysis are necessarily affected by the actual relationships among the actors that operate at different stages of the chain. One must specify whose costs one is accounting for within LCC and, unlike material flows in LCA, this strictly depends on which actor's perspective is the relevant one (Rebitzer and Hunkeler 2003). An exception is hybrid LCC (Nakamura and Kondo 2006a, 2009a), which aims to improve the depth of the analysis, just as with macroeconomic IOA merged with LCA (Suh and Huppes 2005, see for example).

In conclusion, the computational structure of LCC must secure the modelling of the reciprocal interdependences, in terms of linked material flows, among the echelons of a SC of production processes. Issues that belong to inter-organisational cost management can be addressed in this way – an example would be the reduction of the information asymmetry between the buyer and the supplier regarding the relationship between the specifications established by the former and the resulting costs to the latter (Cooper and Slagmulder 2004).

2.3 The Role of Material Flows: LCC in Environmental Management

Material and cost flows play an important role within manufacturing systems in setting the structural interdependences among a supply chain of production processes. Physical aspects in LCC have been taken into account so far only by the environmental meaning of LCC. Such meaning of LCC has been gaining relevance since LCA was developed in the 1990s, because the lack of complementary environmental cost information has been perceived as a major shortcoming of the analysis, from a managerial point of view (Fava and Smith 1998, Steen 2007, Weitz et al. 1994). Although having no roots in the environmental domain, LCC has seen almost a renaissance in recent years because of environmental issues. The environmental meaning of LCC has been exhaustively defined in literature. It can be viewed as either a way of incorporating costs into LCA (Norris 2001, Shapiro 2001, White et al. 1996) or as a way of deriving the full environmental cost of products with the aid of LCA (Epstein 1996, 2008, Epstein and Roy 1997, Schaltegger and Burritt 2000). Aside from any reference to LCA, LCC has been understood as the projected financial consequences of environmentally relevant decisions throughout the product life cycle (Bennett and James 2000b, Burritt et al. 2002, Epstein and Wisner 2002, Kreuze and Newell 1994). Yet, as Emblemsvåg (2003) puts it, much confusion still exists in that area. Especially, if LCC is understood to be used in combination with LCA, such confusion calls for a formalised computational structure (Settanni 2008).

The environmental concept of LCC summarises, at least in theory and depending upon definitions, all the fundamental tasks of environmental cost management as outlined by Loew (2003). However, the approach that has prevailed so far is the combination of separate yet consistent tools: LCC and LCA. They are seen as complementary tools and their parallel implementation excludes any formal integration of the former into the latter (Udo de Haes et al. 2004). Nonetheless, the production alternatives are usually ranked accordingly in a number of ways (see for example Bennett et al. 1998, Huppes and Ishikawa 2005, Kicherer et al. 2007, Schaltegger and Burritt 2000, Schmidt 2003, Vögtlander et al. 2002), and the measures thus obtained concur to the definition of the concept of *eco-efficiency*, which can be seen as part of such a pragmatic, goal-driven set of tools as sustainability accounting (Schaltegger and Burritt 2010).

If LCA and LCC are based on the same principles, so that they can be combined, the most appropriate link between them is the inventory of physical flows which is to be set up in LCA. It provides a good basis for deriving the costs associated with material and energy flows (Rebitzer 2002). LCA and LCC can be different in scope yet consistent as long as the system boundaries are the same (Rebitzer and Nakamura 2008). Nevertheless, examples of LCA and LCC clearly combined via inventory are seldom provided (Notarnicola et al. 2004, Vizayakumar et al. 2002). Indeed, the traditional concept of LCC as a cash flow analysis is almost without exception used in combination with the outcomes of an LCA although it actually deviates from the basic features of the LCA model (Huppes et al. 2004). Examples include a variety of durable goods (Gu et al. 2008, Hellgren 2007, Hochschorner and Finnvenden 2006, Junnila 2008, Schmidt and Butt 2006, Schwab Castella et al. 2009), waste and effluent treatment services (Lim et al. 2008, Reich 2005, Sampattagul et al. 2004), electric energy (El-Kordy et al. 2002, Kannan et al. 2007, Roth and Ambs 2004) and food production plants (Roy et al. 2006), just to mention a few.

Ultimately, when it comes to assessing costs, the insight into how the underlying information about material flows has been collected, organised and computed may prove to be poorer in LCC than in LCA and SCM. Thus, invoking LCC as the economic counterpart of LCA seldom entails practical insights into how costs, especially the environmentally related ones, are assigned to processes and products.

3 Input–Output Life Cycle Modelling for Costing Purposes

3.1 General Aspects of the Input–Output Approach

It is argued here that input–output analysis (IOA) can be applied to costing methods like LCC. IOA formalises in a tabular form, by using matrices and linear algebra, the structure of relationships underlying the reciprocally linked elements – sectors, firms and individual processes – of a production-economic system. More importantly, the environmental extensions of IOA have been widely discussed in literature providing analytical criteria to deal with the material-flow-based assignment of end-of-pipe treatment/abatement costs to processes and then to products. The mathematics of IOA has been developed in the field of macroeconomics and its limitations and assumptions are well-known (ten Raa 2005). Because of its properties, however, IOA has been adopted within several systemic methods of modelling production-economic systems (Bouman et al. 2000) such as LCA (Heijungs 2001, Heijungs and Suh 2002), SCM (Albino et al. 2002), material flow analysis (Kytzia et al. 2004, Xue et al. 2007) and hybrid LCC (Nakamura and Kondo 2006a, 2009a). IOA has also been effectively applied to solve several problems of cost accounting – especially cost allocation in divisionalised enterprises – and production planning though the original principles had to be properly adapted to meet such purposes (Gambling and Nour 1970, Grubbström and Tang 2000, Ijiri 1968).

To adopt a computational structure which is based on IOA at the microeconomic level is to model the structural elements of manufacturing processes. An input–output accounting scheme is especially useful in situations where the manufacturing systems are made up of interacting processes and many or most of such processes require each other's outputs as inputs. It clearly shows similarities with other methods which employ simultaneous equations though not matrices (Schmidt 2005, Sushil 1992).

The analysis in this chapter differs from the previous chapters in that it addresses production planning and cost accounting simultaneously while taking into account issues concerning multi-product systems, closed-loop recycling, pollution abatement processes as well as the cost of producing and then disposing of such process inefficiencies as wastes/by-products. Expanding the model downstream, the repercussions of different product-process design solutions on the associated whole-of-life costs can be assessed. Instead, expanding the model upstream issues similar to open-book accounting and inter-organisational cost management can be addressed, at least theoretically viewing the partners involved as a vertically integrated firm.

The input–output modelling of LCC entails the following steps that will be discussed in detail. First, the manufacturing system is represented as a process network, then a corresponding inventory of physical flows is set up by using matrix notation. Two balancing procedures are then performed by means of basic linear algebra in order to obtain a quantitative picture of the resources required, produced and wasted while meeting an exogenous production plan. Finally, the assignment of production costs is carried out relying on the previously obtained grid of material and energy flows.

3.2 Process Network Representation

A manufacturing system can be represented as a network of production processes which may belong to different actors, from the raw material supplier to the final user, then to the end-of-life actors. Processes are reciprocally linked by flows of materials, energy and information. The dynamic behaviour of such network can be described in terms of these structural interdependences and is relevant for accounting purposes (Schmidt 2005). The elements of the process network can be specified in a generalised way as follows (this notation expresses natural numbers):

l plants;

n ($n = n_I + n_{II}$) processes which are linked by supplier/customer relationships, of which:

- n_I production processes
- n_{II} treatment processes

m resource types ($m = n + n_M + n_H + n_W + n_R$), of which

- n main outputs of processes
- n_M externally purchased inputs
- n_H other cost drivers
- n_W secondary products or waste types
- n_R environmental flows

Plants are items of equipment by means of which the transformation of inputs into outputs takes place. The choice of plants to be considered reflects the sequence of operations to be performed during the planning period and defines the system boundaries consistently with the SC issues discussed in Sect. 4.2.2. Processes are a set of activities that are homogeneous with respect to their output. They can be seen as different ways of running plants to make different products, thus $n \geq l$. A single piece of plant can be occupied by more than one such process. The number of detailed processes to be considered depends upon the scope of the analysis. The choice of focussing on conveniently aggregated processes instead of activities is mainly due to the lack of details which may characterise SMEs enterprises. An important difference, from a modelling perspective, between the n_I production processes and the n_{II} treatment processes is that the main outp ut produced by the latter is in fact a service measured as the amount of effluents of different types which has been treated. Also the use phase of a given marketable product can be considered as a process. This allows accounting for the post-purchase and end-of-life costs.

For illustrative purposes, consider the hypothetical manufacturing system depicted in Fig. 4.1.

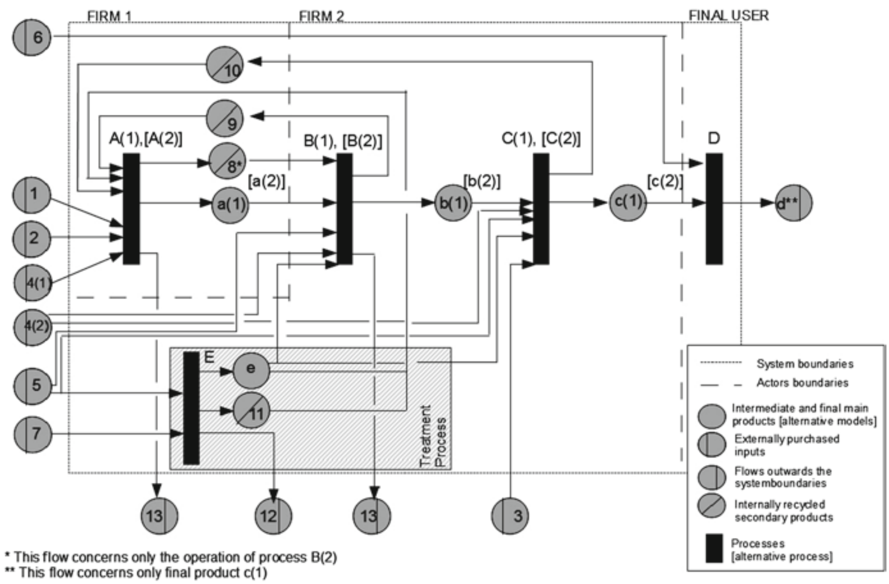

Fig. 4.1 A generic manufacturing system network

In Fig. 4.1, circles (called *places*) are local states of the system, for example available raw materials and parts, completed intermediate and final products, and effluents released into the environment. Rectangles called *transitions* are active system components that is processes. Circles placed before rectangles show preconditions that are to be satisfied before an event, namely a process run, occurs at a given time. (To save space, circles in Fig. 4.1 may represent more than one resource.) Circles placed after rectangles show the outputs delivered after the event has occurred.

The network example is made of three production plants *A*, *B* and *C*. Plant *A* is controlled by Firm 1 and it runs in two different ways in order to produce either intermediate product *a*(1) or *a*(2). Plants B and C are controlled by Firm 2, instead. They also can each run in two different ways. B produces *b*(1) or *b*(2) whereas *C* produces two kinds of final products *c*(1) or *c*(2). Assuming that product *c* is a durable commodity, its use can be considered a further stage. In order to account for post-purchase costs of, say, product *c*(1), process *D* is defined, which is controlled by the final user and fictitiously generates output *d*, namely product *c*(1) after being used for one year. Scraps from *B* and *C* are recycled as secondary inputs in *A* without being further processed. One waste treatment process, *E*, su pports *A*, *B* and *C*, though being controlled by Firm 2. It produces a treatment service, *e*, that is measured by the amount of waste generated by *A* and *C* and then processed by *E*. In this example, $l=4$ (the use stage is excluded) and $n=8$. Furthermore, the waste, after being treated, is recycled by *A*, *B* and *C*. The treatment by-products are disposed of externally.

3.3 Inventory Set Up

Once the relationships among the elements of the manufacturing system network have been represented, the underlying *technological model* can be defined by means of the enterprise input–output accounts (EIOA). The model is built bottom-upwards from the basic operations which it purports to illustrate (Gambling 1968). Using matrices, EIOA records material flows among well specified units – whether they are organisations or processes within the same organisation. These physical relationships, including the environmental aspects, are then turned into financial transactions by means of matrix operations (Lin and Polenske 1998).

An exogenous demand of intermediate and final commodities is to be specified for a planning period. Given the technological model and the final deliveries, LCC - based on IOA and – using one computational procedure – allows assess the system's activity levels, the expected resource requirement, the associated environmental burdens and, consequently, the internal production costs at each stage of the operations chain. This foresight-orientated approach relies upon the anticipated performances of a manufacturing system and it has been defined as activity-level analysis (Heijungs 2001). It is consistent with other applications of IOA to cost planning at the enterprise level (Boons 1998, Feltham 1968, Livingstone 1969) and with standard costing as well.

To build a technological model of the enterprise/SC, each process included within the chosen boundaries must be described in terms of the parameters that reasonably approximate its real characteristics. These parameters concern material inflows and outflows, plant capacity usage, run size, cycle time, and other elements that can be considered as cost drivers linked to the operation of a process. The outcomes of the cost model heavily rely on how the inventory of physical flows has been structured.

All data concerning the elements of the network depicted in Fig. 4.1 are to be collected and arranged in a tabular form, which is suitable for successive computations, using matrices. To define the necessary matrices several conventions are adopted here.

1. The sequence of n processes, that is the active components of the network, must be read column-wise. As already mentioned, different batches of products can be associated with different process operating parameters because of different design specifications. Each process must then be represented as a separate entity – and, as a consequence, recorded as a separate column – for each product model it produces. However, the capacity of the plants must constrain the operation of those processes involved by the production plan (Gambling 1968, Tuckett 1969). This way of accounting for multiple-product plants is required by the assumption that the process technology is fixed – which characterises static IOA.
2. The m resource types, that is the passive components of the network, can be read row-wise. They are the intermediate, final or secondary products the processes deliver and the inputs they require. Resources include commodities as well as cost drivers of different nature. They are labelled univocally and expressed in the appropriate physical units. To facilitate cost assignment, resources that are purchased externally should be recorded as different sub-types, though being physically the same, to reflect different purchasing conditions that may occur, for example, at different stages of the operations chain.

The subset of resource types to be considered initially corresponds to the n main outputs of processes, that is those intermediate and final products which are both supplied and required by the processes or meet the market demand. The amounts of such products entering and leaving each process must be recorded separately within two distinct matrices. In economics, they are traditionally addressed as the *use table* and the *supply (or make) table*, respectively (ten Raa 2005).

Within the *use table* $\mathbf{U}$, of dimensions $n \times n$, the generic element u_{ij} $(i,j=1\ldots n)$ describes the amount of product i supplied by other processes (however, self-consumption may also occur) and used as an input by process j to produce the amount of outputs which is recorded as the jth column of another table $\mathbf{V}$, called *supply table*, of dimensions $n \times n$. The latter's generic element v_{ij} describes the amount of product i delivered by process j. Both $\mathbf{U}$ and $\mathbf{V}$ are positive semi-definite.

It is conventionally assumed that process j produces product j as its main output. Hence, the main outputs of the system considered can be read along the main diagonal of $\mathbf{V}$. The choice of a process main output can be a subjective and difficult one, especially if processes are multifunctional, that is they produce each other's products. One possible approach to represent multifunctional processes is to decompose the supply table into its on-diagonal and off-diagonal elements (ten Raa 2005). By convention, only the former will be considered as the system's gross output $\mathbf{V}$, whereas the latter will be accounted for as wastes/by-products, assuming that they are the trigger for an increased demand for waste treatment rather than the cause of a reduction of the main outputs they compete with (Nakamura and Kondo 2002). With reference to the illustrative example, the hypothetical entries of **U** and **V** are shown in Table 4.1 (in this case $n=8$, being $n_I=7$ and $n_{II}=1$), reflecting the relationships represented in Fig. 4.1.

It should be noted that those amounts recorded in **U** and **V** are not balanced. At this point of the analysis processes are considered as stand-alone entities and they are

Table 4.1 Supply and use tables

V: Make matrix (output)				Processes							
				(I)							(II)
	Network node		Unit	$A(1)$	$A(2)$	$B(1)$	$B(2)$	$C(1)$	$C(2)$	D	E
	$a(1)$	Main output a(1)	t	49.20	–	–	-	–	–	–	–
	$a(2)$	Main output a(2)	t	–	48.06	–	–	–	–	–	–
	$b(1)$	Main output b(1)	t	–	–	5.04	–	–	–	–	–
(I)	$b(2)$	Main output b(2)	t	–	–	–	2.67	–	–	–	–
	$c(1)$	Main output c(1)	t	–	–	–	–	5.55	–	–	–
	$c(2)$	Main output c(2)	t	–	–	–	–	–	5.51	–	–
	d	Main output c(1) – used	m^2	–	–	–	–	–	–	100.00	–
(II)	e	Waste treatment	t	–	–	–	–	–	–	–	17.00

U: Use matrix (input)				Processes							
				(I)							(II)
	Network node		Unit	$A(1)$	$A(2)$	$B(1)$	$B(2)$	$C(1)$	$C(2)$	D	E
	$a(1)$	Main output a(1)	t	–	–	5.80	1.17	–	–	–	
	$a(2)$	Main output a(2)	t	–	–	–	2.2	–	–	–	–
	$b(1)$	Main output b(1)	t	–	–	–	–	5.5	–	–	–
(I)	$b(2)$	Main output b(2)	t	–	–	–	–	–	5.04	–	–
	$c(1)$	Main output c(1)	t	–	–	–	–	–	–	2.90	–
	$c(2)$	Main output c(2)	t	–	–	–	–	–	–	–	–
	d	Main output c(1) – used	m^2	–	–	–	–	–	–	–	–
(II)	e	Waste treatment	t	–	–	–	–	–	–	–	–

Flows not balanced

described according to their technical specifications, as if they were cooking recipes. The values to be accounted for are those expected to be delivered by one *run* of a given process. The size of that run is to be defined as the basic operating level of the process that is meaningful for planning purposes according to the features of the corresponding plant. Hence, the run size may correspond to one batch of products, one unit, etc., or to the amount of output delivered per unit of time, for example 1 h, one shift, etc. In the former case, the amounts recorded are referred to as flows, whereas in the latter case as flow rates.

Once the relevant flows (and/or flow rates) are recorded within the appropriate matrices, it is necessary to turn them into a comprehensive resource balance that is consistent with the final deliveries planned for a given period. Within the proposed computational structure of LCC this is accomplished by the balancing equations that will be introduced in Sect. 4.3.4. This contrasts with the approaches usually adopted in IOA and EIOA which involve taking into account overall balanced physical transactions that have characterised a given system in a period of time (usually one year) and then using those aggregated quantities to describe its structure in terms of technical coefficients. In other words, the outcome of the proposed approach corresponds to the usual starting point in IOA.

Within Table 4.1 those n_I rows and columns that refer to the production processes have been grouped and labelled as *(I)*, whereas those n_{II} rows and columns that refer to the treatment processes have been grouped and labelled as *(II)*. From now on, this notation will be used to address the partitions of a given matrix by means of subscripts. These subscripts include a row and a column index indicating respectively the relevant row and column group. For example $\mathbf{U}_{I,I}$ is the $n_I \times n_I$ upper left partition of matrix **U**, that records each process demand of outputs that are produced by other production processes.

The system's net output matrix **Z** can be computed as follows:

$$\mathbf{Z} = \mathbf{V} - \mathbf{U} = \left(\begin{array}{ccccccc|c} 49.20 & 0 & -5.80 & -1.17 & 0 & 0 & 0 & 0 \\ 0 & 48.60 & 0 & -2.2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5.04 & 0 & -5.50 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.67 & 0 & -5.04 & 0 & 0 \\ 0 & 0 & 0 & 0 & 5.55 & 0 & -2.9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 5.51 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 100 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 & 0 & 17.00 \end{array}\right) \tag{4.1}$$

Z is referred to as the technology matrix. Within **Z** the inflows are associated with negative figures and the outflows with positive ones. Yet, the elements of the $n_{II} \times n_I$ partition $\mathbf{Z}_{II,I}$, that express the demand for waste treatment of each process amount to zero at this stage. Indeed, such demand is not an exogenous element. Instead, it has to be calculated, as will be shown later, according to the amount of waste produced by each process which is not recycled internally.

The additional elements that must be taken into account within the inventory are shown in Table 4.2, addressed as matrix **B**, the partitions of which are discussed below.

Table 4.2 Other resources generated and used by the system

	Matrix **B**			Processes							
				(I)							(II)
	Network node		Unit	*A*(1)	*A*(2)	*B*(1)	*B*(2)	*C*(1)	*C*(2)	*D*	*E*
−**M**	1	Raw material 1	t	−18.00	−20.00	–	–	–	–	–	–
	2	Raw material 2	t	−21.00	−21.44	–	–	–	–	–	–
	3	Raw material 3	t	–	–	–	–	−0.27	−0.92	–	–
	4(1)	Water (firm 1)	m^3	−10.00	−8.00	–	–	–	–	–	–
	3	Water (firm 2)	m^3	–	–	–	–	−1.45	−1.2	–	–
	4(1)	Fossil fuel (firm 1)	m^3	−1,380.00	−2,500.00	–	–	–	–	–	–
	4(2)	Fossil fuel (firm 2)	m^3	–	–	−40.00	−42.00	−212.00	−200.00	–	–
	4(1)	Electric energy (firm 1)	MWh	−3.30	−3.80	–	–	–	–	–	–
	5	Electric energy (firm 2)	MWh	–	–	−0.14	−0.132	−0.05	−0.08	–	−3.82
	6	Maintenance materials (use stage)	L	–	–	–	–	–	–	−9.00	–
	7	Treatment raw materials	t	–	–	–	–	–	–	–	−0.50
−**H**		Cycle time A	t	−28.40	−26.30	–	–	–	–	–	–
		Cycle time B	t	–	–	−2.00	−2.03	–	–	–	–
		Cycle time C	t	–	–	–	–	−1.08	−1.25	–	
		Cycle time E	t	–	–	–	–	–	–	–	−13
$\bar{\mathbf{N}}$		Waste type 1 (out)	t	2.00	1.60	–	–	–	–	–	–
		Waste type 2 (out)	t	–	–	0.76	0.09	0.19	0.18	–	–
		Waste type 3 (out)	t	1.60	1.58	–	–	1.58	1.57	–	–
		Waste type 4 (out)	t	–	–	–	–	–	–	–	16.70

(continued)

Table 4.2 (continued)

Matrix **B**				Processes							
				(I)							(II)
	Network node		Unit	$A(1)$	$A(2)$	$B(1)$	$B(2)$	$C(1)$	$C(2)$	D	E
−**N̲**	8	Waste type 1 (in)	t	–	–	–	−0.20	–	–	–	–
	9	Waste type 2 (in)	t	−0.20	−0.40	–	–	–	–	–	–
	10	Waste type 3 (in)	t	–	–	–	–	–	–	–	–
	11	Waste type 4 (in)	t	−3.60	−1.40	–	–	−0.10	−0.10	–	–
R	12	External waste disposal	t	–	–	–	–	–	–	–	0.30
	13	CO_2 emissions	t	2.66	4.81	0.077	0.08	0.408	0.385	–	–
−**C**		Capacity A	%	−2.50	−2.00	–	–	–	–	–	–
		Capacity B	%	–	–	−0.20	−0.20	–	–	–	–
		Capacity C	%	–	–	–	–	−0.20	−0.20	–	–
		Capacity E	%	–	–	–	–	–	–	–	−3.00

Flows not balanced

It should be noted that also the amounts recorded in **B** are not balanced, since they are consistent with those recorded in **Z**. Also the signs in Table 4.2 have been assigned consistently with those in **Z**.

1. The amount of externally purchased input g required by process j to deliver its outputs corresponds to the generic element m_{gj} of matrix **M**, of dimensions $n_M \times n$. (In the numerical example $n_M = 11$.) The externally purchased inputs are those absorbed by one or more processes but not produced by any of them, that is they are supplied by black box processes. The latter cannot be controlled, given the actual SC relationships, and consequently, cannot be described in detail. Thus, their contribution to the overall manufacturing cost, given the market price paid to suppliers, can only be influenced by the consumption rates. **M** also records those cost drivers that allow tracing costs that are not associated with the direct consumption of resources. Consider, for example, the variable component of the cost of utilities. An estimate of a process' electricity consumption, measured as MWh, can be in fact calculated if the equipment adjusted installed power and the time the process is expected to run are known.
2. Matrix **H**, of dimensions $n_H \times n$, records as its elements the other relevant cost drivers (in the numerical example $n_H = l = 4$). These parameters are related to the operation of each process, though not being physical in nature. Thus, they cannot be represented as network elements. They allow the driver tracing of budgeted conversion costs to processes. An example is cycle time of each process, measured in machine hours.
3. The secondary products or waste types are those commodities which are obtained from the operation of processes and are neither delivered as main inputs to any downstream process within the defined boundaries, nor meet the final deliveries. The net generation of waste k by process j is recorded as the generic element $\overline{n}_{kj}$ of matrix $\overline{\mathbf{N}}$, of dimensions $n_W \times n$. (in the numerical example $n_w = 4$). It undergoes the treatment processes except for the quantity which is recycled internally as a secondary input within the operation chain considered. The latter is recorded separately as $\underline{n}_{kj}$ within matrix $\underline{\mathbf{N}}$, of dimensions $n_W \times n$, as well. Each process is assumed either to produce a given waste k or to use it as a secondary input (Nakamura and Kondo 2009b), that is $\forall j, \forall k : \overline{n}_{kj} \times \underline{n}_{kj} = 0$. Thus waste outflows do not include intra-process recycling. Though this is not the only way to proceed, especially in SCM (Albino et al. 2008, Albino and Kühtz 2004), it seems most convenient for cost accounting purposes.
4. The environmental flows are those released into the natural environment or extracted from it, that causes environmental interventions. These flows are recorded within the $n_R \times n$ matrix **R** (In the numerical example $n_R = 2$). They can be seen as cost drivers to assign environmental costs, especially the external failure ones. Examples could be the cost of purchasing pollutant emission allowances, and other kind of permits to discharge a given substance into the environment. The demand for externally purchased waste treatment services is conveniently recorded in **R**.

5. Matrix **C**, of dimensions $l \times n$, records for each process the corresponding plants' capacity that is used when the process is run at its base activity level. In the numerical example $l = 4$. The capacity is to be consistent with the planning horizon that has been chosen (a month, a week, etc.). From Table 4.2 one can see that each run of process $B(1)$ takes 2 h and uses 0.20% of the corresponding, say monthly, plant B's capacity to produce 6.10 t of the main product $b(1)$.

All the information described so far can be arranged within just one matrix **A** of dimensions $(m + n_w) \times n$:

$$\mathbf{A} = \begin{pmatrix} \mathbf{Z} \\ \mathbf{B} \end{pmatrix} \tag{4.2}$$

Hypothetical values for **A** are shown in Table 4.3. (In the numerical example $(m + n_w) = 37$).

Table 4.3 also gives the matrix notation that will be made reference to in the next sections. In particular, the partitions of matrix **A** have been identified by means of subscripts. The subscript can include a combination of symbols like '*(I)*','*(II)*' and '•'. Whereas the first two have been already described, the latter symbol is used as the first (second) element of the matrix's subscript if all the rows (columns) of a matrix are being considered.

At this stage, those variables that can be related to the level of activity of each process – interpreted here as process runs – are assumed to have been identified and quantified. Each column of matrix **A** represents a *technique*. Hence, it must reflect the rigid relationships between mass and energy inflows and outflows that characterise each stage of the production-economic system considered.

3.4 Balancing Procedures

In the previous section, processes have been considered as stand-alone entities and described according to their technical specifications, as if they were 'cooking recipes'. The balancing procedures start from this inventory of physical flows and cost drivers and end with an overall balance of resources that covers the entire operation chain. They involve basic matrix operations – subtraction, product, inversion, transposition, diagonalisation – that can be carried out with the aid of commonly used electronic spreadsheets.

As a premise, a production plan, or final deliveries, must be specified for a specific planning horizon, say 1 month. This sets the amount of final and intermediate product models that have been planned to be produced in that month. Table 4.4 provides a numerical example, leaving aside the inventories for now.

The first balancing procedure is based on the condition that the net output of the production processes must meet the exogenous final deliveries recorded in the production plan. To accomplish this task, each production process described within the inventory is required to perform a number of runs, which is the unknown activity level for that process. The treatment processes will be considered only after the amount of each waste type generated and recycled within the production processes is calculated. The activity levels of production processes must be calculated, and then used to scale-up or balance all the flows recorded within the inventory. The amount of waste treatment demanded by each production process is calculated accordingly. This demand must be met by the output of those treatment processes that are run internally. Thus, another balancing procedure is required in order to assess the activity levels the treatment processes must operate at in order to accom plish this task. Both procedures are described fully below.

Making reference to the numerical example, the balancing condition can be expressed as the following system of linear equations:

$$\begin{cases} 49.20 \cdot s_1 - 5.80 \cdot s_3 - 1.17 \cdot s_4 = y_1 \\ 48.06 \cdot s_2 - 2.20 \cdot s_4 = y_2 \\ 5.04 \cdot s_3 - 5.50 \cdot s_5 = y_3 \\ 2.67 \cdot s_4 - 5.04 \cdot s_6 = y_4 \\ 5.55 \cdot s_5 - 2.90 \cdot s_7 = y_5 \\ 5.51 \cdot s_6 = y_6 \\ 100 \cdot s_7 = y_7 \end{cases} \quad (4.3)$$

where y_i $(i=1\ldots n_I)$ are the entries of the production plan (known variables) whereas s_i $(i=1\ldots n_I)$ are the scaling factors (unknown variables). System (4.3) can be expressed in compact matrix notation as:

$$\mathbf{Z}_{I,I} \cdot \mathbf{s}_I = \mathbf{y}_I \quad (4.4)$$

The $n_I \times n_I$ matrix $\mathbf{Z}_{I,I}$ can be found in the upper left partition of Table 4.3. The $n_I \times 1$ final delivery vector $\mathbf{y}_I$ corresponds to the upper partition of Table 4.4. The $n_I \times 1$ scaling vector $\mathbf{s}_I$ is defined whose entries represent the activity levels the production processes are required to operate at in order to meet the production plan. It follows that:

$$\mathbf{s}_I = \mathbf{Z}_{I,I}^{-1} \cdot \mathbf{y}_I = \begin{pmatrix} 0.02032 & 0 & 0.02339 & 0.00890 & 0.02317 & 0,00817 & 0.00067 \\ 0 & 0.02081 & 0 & 0.01714 & 0 & 0.01568 & 0 \\ 0 & 0.19841 & 0 & 0.19662 & 0 & 0.00570 & \\ 0 & 0 & 0 & 0.37453 & 0 & 0.34258 & 0 \\ 0 & 0 & 0 & 0 & 0.18018 & 0 & 0.00522 \\ 0 & 0 & 0 & 0 & 0 & 0.18149 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.01000 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 800 \\ 25.000 \end{pmatrix} = \begin{pmatrix} 23.32 \\ 12.54 \\ 142.55 \\ 274.06 \\ 130.63 \\ 145.19 \\ 250 \end{pmatrix} \quad (4.5)$$

Equation 4.5 is based on the inversion of matrix $\mathbf{Z}_{I,I}$. Its inverse, provided that it exists, is $\mathbf{Z}_{I,I}^{-1}$. The conditions that must be satisfied for a matrix to be invertible, as well as the use of sequential methods as an alternative to the matrix inversion, are fundamental issues that have been exhaustively treated elsewhere (Suh and Heijungs 2007, ten Raa 2005) and will not be discussed here.

Table 4.3 Input–output representation of the system

Matrix **A**			
		Network node	
$\begin{bmatrix} \mathbf{Z}_{I,I} & \mathbf{Z}_{I,II} \\ \mathbf{Z}_{II,I} & \mathbf{Z}_{II,II} \end{bmatrix}$	(I)	$a(1)$	Main output a(1)
		$a(2)$	Main output a(2)
		$b(1)$	Main output b(1)
		$b(2)$	Main output b(2)
		$c(1)$	Main output c(1)
		$c(2)$	Main output c(2)
		d	Main output c(1) – used
	(II)	e	Waste treatment
$\begin{bmatrix} \mathbf{B}_{\bullet,I} & \mathbf{B}_{\bullet,II} \end{bmatrix}$	$\begin{bmatrix} -\mathbf{M}_{\bullet,I} & -\mathbf{M}_{\bullet,II} \end{bmatrix}$	1	Raw material 1
		2	Raw material 2
		3	Raw material 3
		4(1)	Water (firm 1)
		3	Water (firm 2)
		4(1)	Fossil fuel (firm 1)
		4(2)	Fossil fuel (firm 2)
		4(1)	Electric energy (firm 1)
		5	Electric energy (firm 2)
		6	Maintenance materials (use stage)
		7	Treatment raw materials
	$\begin{bmatrix} -\mathbf{H}_{\bullet,I} & -\mathbf{H}_{\bullet,II} \end{bmatrix}$		Cycle time A
			Cycle time B
			Cycle time C
			Cycle time E
	$\begin{bmatrix} \overline{\mathbf{N}}_{I,I} & \overline{\mathbf{N}}_{I,II} \end{bmatrix}$		Waste type 1 (out)
			Waste type 2 (out)
			Waste type 3 (out)
	$\begin{bmatrix} \overline{\mathbf{N}}_{II,I} & \overline{\mathbf{N}}_{II,II} \end{bmatrix}$		Waste type 4 (out)
	$\begin{bmatrix} -\underline{\mathbf{N}}_{I,I} & -\underline{\mathbf{N}}_{I,II} \end{bmatrix}$	8	Waste type 1 (in)
		9	Waste type 2 (in)
		10	Waste type 3 (in)
	$\begin{bmatrix} -\underline{\mathbf{N}}_{II,I} & -\underline{\mathbf{N}}_{II,II} \end{bmatrix}$	11	Waste type 4 (in)
	$\begin{bmatrix} \mathbf{R}_{\bullet,I} & \mathbf{R}_{\bullet,II} \end{bmatrix}$	12	External waste disposal
		13	CO_2 emissions
	$\begin{bmatrix} -\mathbf{C}_{\bullet,I} & -\mathbf{C}_{\bullet,II} \end{bmatrix}$		Capacity A
			Capacity B
			Capacity C
			Capacity E

Flows not balanced

	Processes							
	(I)							(II)
Unit	*A*(1)	*A*(2)	*B(1)*	*B*(2)	*C*(1)	*C*(2)	*D*	*E*
t	49.20	–	−5.80	−1.17	–	–	–	–
t	–	48.06	–	−2.20	–	–	–	–
t	–	–	5.04	–	−5.50	–	–	–
t	–	–	–	2.67	–	−5.04	–	–
t	–	–	–	–	5.55	–	2.09	–
t	–	–	–	–	–	5.51	–	–
m^2	–	–	–	–	–	–	100.00	–
t	–	–	–	–	–	–	–	17.00
t	−18.00	−20.00	–	–	–	–	–	–
t	−21.00	−21.44	–	–	–	–	–	–
t	–	–	–	–	−0.27	−0.92	–	–
m^3	−10.00	−8.00	–	–	–	–	–	–
m^3	–	–	–	–	−1.45	−1.2	–	–
m^3	−1,380.00	−2,500.00	–	–	–	–	–	–
m^3	–	–	−40.00	−42.00	−212.00	−200.00	–	–
MWh	−3.30	−3.80	–	–	–	–	–	–
MWh	–	–	−0.14	−0.132	−0.05	−0.08	–	−3.82
L	–	–	–	–	–	–	−9.00	–
t	–	–	–	–	–	–	–	−0.50
t	−28.40	−26.30	–	–	–	–	–	–
t	–	–	−2.00	−2.03	–	–	–	–
t	–	–	–	–	−1.08	−1.25	–	
t	–	–	–	–	–	–	–	−13.00
t	2.00	1.60	–	–	–	–	–	–
t	–	–	0.76	0.09	0.19	0.18	–	–
t	1.60	1.58	–	–	1.58	1.57	–	–
t	–	–	–	–	–	–	–	16.70
t	–	–	–	−0.20	–	–	–	–
t	−0.20	−0.40	–	–	–	–	–	–
t	–	–	–	–	–	–	–	–
t	−3.60	−1.40	–	–	−0.10	−0.10	–	–
t	–	–	–	–	–	–	–	0.30
t	2.66	4.81	0.077	0.08	0.408	0.385	–	–
%	−2.50	−2.00	–	–	–	–	–	–
%	–	–	−0.20	−0.20	–	–	–	–
%	–	–	–	–	−0.20	−0.20	–	–
%	–	–	–	–	–	–	–	−3.00

Table 4.4 Production plan for 1 month

	Network node		Unit	y_i
(I)	$a(1)$	Main output a(1)	t	0.00
	$a(2)$	Main output a(2)	t	0.00
	$b(1)$	Main output b(1)	t	0.00
	$b(2)$	Main output b(2)	t	0.00
	$c(1)$	Main output c(1)	t	0.00
	$c(2)$	Main output c(2)	t	800.00
	d	Main output c(1) – used	m^2	25,000.00
(II)	e	Waste treatment	t	0.00

Once the scaling vector has been calculated, and recalling that only the production processes are concerned at this stage of the analysis, the entries on the left side of Table 4.3 can be balanced. They correspond to the partition $\mathbf{A}_{\bullet,I}$ of matrix $\mathbf{A}$ of dimensions $(m+n_w)\times n_I$. One characterising assumption of IOA is that of constant returns to scale. Hence, scaling up the base activity level of a process implies that the amounts of outputs produced and the inputs required have been multiplied by the same scaling factor. Formally:

$$\mathbf{A}_{\bullet,I}\cdot\hat{\mathbf{s}}_I = \begin{pmatrix} \tilde{\mathbf{Z}}_{I,I} \\ \tilde{\mathbf{Z}}_{II,I} \\ \tilde{\mathbf{B}}_{\bullet,I} \end{pmatrix} \tag{4.6}$$

where $\hat{\mathbf{s}}_I$ is the diagonalised scaling vector $\mathbf{s}_I$. Also, $\tilde{\mathbf{Z}}_{II,I}=\mathbf{0}$. The outcomes of Eq. 4.6 are shown in Table 4.5, as well as the details of the balancing operation for each partition of $\mathbf{A}_{\bullet,I}$.

The outcome of the procedure described so far is only a partially-balanced inventory and is necessary to proceed to the assessment of the amount of internally-provided end-of-pipe treatment services demanded by the production processes. Such amount is measured as the balanced amount expressed in mass of different waste types which are processed by each treatment service. In this way, the entries of matrix $\tilde{\mathbf{Z}}_{II,I}$ in Eq. 4.6 can be determined.

This step is necessary especially in those situations where there are not as many treatment processes as waste types, that is $n_w>n_{II}$. The latter correspondence was assumed, instead, by the earlier formulations of environmentally extended IOA (Leontief 1970).

For each waste type, the amount of waste generated must not include intra-process recycling, by convention. Then, it must be turned into the amount of waste that has not been recycled internally. Such amount is to be further specified according to which treatment process it undergoes. This procedure has been originally formulated in economics as the waste input–output model by Nakamura and Kondo (2009b, 2002).

The entries of partition $[\overline{\mathbf{N}}_{I,I} \cdot \hat{\mathbf{s}}_I]$ of Table 4.5 express the amount of each waste type k ($k=1\ldots3$) generated by the production processes. Row totals (i.e. for each waste type) can be read in the last column of Table 4.5. They are recorded as the entries of a column vector ρ_I as follows: $\forall k, (\rho_I)_k = \sum_{j=1}^{n_I} (\overline{\mathbf{N}}_{I,I})_{kj} \times (\mathbf{s}_I)_j$. The entries of partition $[-\underline{\mathbf{N}}_{I,I} \cdot \hat{\mathbf{s}}_I]$ of Table 4.5 express the amount of waste recycled internally – called the input of waste. A vector η_I is defined whose elements are the row totals of this partition: $\forall k, (\eta_I)_k = \sum_{j=1}^{n_I} (\underline{\mathbf{N}}_{I,I})_{kj} \times (\mathbf{s}_I)_j$. The internal recycling ratio for each waste type k can then be calculated as

$$r_k = \frac{(\eta_I)_k}{(\rho_I)_k} \tag{4.7}$$

Such ratios can be collected as the entries of a column vector $\mathbf{r}_I = \begin{pmatrix} 0.82 & 0.02 & 0 \end{pmatrix}^T$ (where superscript T means that the vector has been transposed). The percentage of each waste type which is not recycled within the operations chain can be determined as $(\mathbf{I} - \hat{\mathbf{r}}_I) = \begin{pmatrix} 0.18 & 0 & 0 \\ 0 & 0.98 & 0 \\ 0 & 0 & 1 \end{pmatrix}$, where $\mathbf{I}$ is an identity matrix of the appropriate dimensions and $\hat{\mathbf{r}}_I$ is the diagonalised vector $\mathbf{r}_I$. This amount should be assigned to the treatment processes. To this purpose, matrix $\mathbf{Q}$ of dimensions $n_{II} \times n$ is exogenously defined. Its generic element $0 \le q_{lk} \le 1$ indicates which fraction, in weight, of the amount of kth waste that has not been recycled, undergoes the lth treatment. (Its column total must sum up to 1.)

Assume $\mathbf{Q} = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix}$. The whole amount of waste that has not been recycled undergoes the same waste treatment the only one available in the numerical example. Firstly, the coefficients that allow the net generation of waste to be turned into the demand of treatment services are calculated:

$$-\mathbf{Q} \cdot (\mathbf{I} - \hat{\mathbf{r}}_I) = \begin{pmatrix} -0.18 & -0.98 & -1 \end{pmatrix} \tag{4.8}$$

Then, the demand of waste treatment is obtained as follows:

$$\tilde{\mathbf{Z}}_{II,I} = [-\mathbf{Q} \cdot (\mathbf{I} - \hat{\mathbf{r}}_I)](\overline{\mathbf{N}}_{I,I} \cdot \hat{\mathbf{s}}_I) = \begin{pmatrix} -45.64 & -23.40 & -105.76 & -240.78 & -230.62 & -253.46 & 0 \end{pmatrix} \tag{4.9}$$

Given the above information, the next computational step is to calculate the scaling factors for the treatment process. The herein adopted numerical example is the simplest – though most likely – case in which the treatment process requires only inputs that are purchased externally. Instead, if the latter process consumed the outputs produced by the other processes all the scaling factors would be calculated again and the whole system would be rescaled. Indeed, the treatment of waste would increase the demand of the other products and the latter would, in its turn, modify the demand of the waste treatment. Then the activity levels of the whole system would be different from the previously calculated ones in order to capture these reciprocal interdependences.

Table 4.5 Input–output representation of the system

		Network node		Unit	$A(1)$
$\begin{bmatrix}\mathbf{Z}_{I,I}\\ \mathbf{Z}_{II,I}\end{bmatrix}\cdot\hat{\mathbf{s}}_I$	(I)	$a(1)$	Main output a(1)	t	1,147.47
		$a(2)$	Main output a(2)	t	–
		$b(1)$	Main output b(1)	t	–
		$b(2)$	Main output b(2)	t	–
		$c(1)$	Main output c(1)	t	–
		$c(2)$	Main output c(2)	t	–
		d	Main output c(1) – used	m^2	–
	(II)	e	Waste treatment	t	–
$\mathbf{B}_{\bullet,I}\cdot\hat{\mathbf{s}}_I$	$-\mathbf{M}_{\bullet,I}\cdot\hat{\mathbf{s}}_I$	1	Raw material 1	t	−419.81
		2	Raw material 2	t	−489.77
		3	Raw material 3	t	–
		4(1)	Water (firm 1)	m^3	−233.23
		3	Water (firm 2)	m^3	–
		4(1)	Fossil fuel (firm 1)	m^3	−32,185.08
		4(2)	Fossil fuel (firm 2)	m^3	–
		5	Electric energy (firm 1)	MWh	−76.96
		5	Electric energy (firm 2)	MWh	–
		6	Maintenance materials (use stage)	L	–
		7	Treatment raw materials	t	–
	$-\mathbf{H}_{\bullet,I}\cdot\hat{\mathbf{s}}_I$		Cycle time A	t	−662.36
			Cycle time B	t	–
			Cycle time C	t	–
			Cycle time E	t	–
	$\overline{\mathbf{N}}_{I,I}\cdot\hat{\mathbf{s}}_I$		Waste type 1 (out)	t	46.64
			Waste type 2 (out)	t	–
			Waste type 3 (out)	t	37.31
	$\overline{\mathbf{N}}_{II,I}\cdot\hat{\mathbf{s}}_I$		Waste type 4 (out)	t	–
	$[-\underline{\mathbf{N}}_{I,I}\cdot\hat{\mathbf{s}}_I]$	8	Waste type 1 (in)	t	–
		9	Waste type 2 (in)	t	−4.66
		10	Waste type 3 (in)	t	–
	$-\underline{\mathbf{N}}_{II,I}\cdot\hat{\mathbf{s}}_I$	11	Waste type 4 (in)	t	−83.96
	$-\mathbf{R}_{\bullet,I}\cdot\hat{\mathbf{s}}_I$	12	External waste disposal	t	–
		13	CO_2 emissions	t	62.04
	$-\mathbf{C}_{\bullet,I}\cdot\hat{\mathbf{s}}_I$		Capacity A	%	−58.30
			Capacity B	%	–
			Capacity C	%	–
			Capacity E	%	–

Flows balanced

Processes						
(I)						
A(2)	*B*(1)	*B*(2)	*C*(1)	*C*(2)	*D*	Totals
–	−826.81	−320.66	–	–	–	–
602.95	–	−602.95	–	–	–	–
–	718.47	–	−718.47	–	–	–
–	–	731.76	–	−731.76	–	–
–	–	–	725.00	–	−725.00	–
–	–	–	–	800.00	–	800.00
–	–	–	–	–	25,000.00	25,000.00
–	–	–	–	–	–	–
−250.91	–	–	–	–	–	−670.72
−268.98	–	–	–	–	–	−758.75
–	–	–	−35.27	−133.58	–	−168.84
−100.37	–	–	–	–	–	−333.59
–	–	–	−189.41	−174.22	–	−363.64
−31,364.37	–	–	–	–	–	−63,549.45
–	−5,702.13	−11,510.84	−27,693.69	−29,038.11	–	−73,944.78
−47.67	–	–	–	–	–	−124.64
–	−19.95	−36.17	−6.53	−11.61	–	−74.28
–	–	–	–	–	−2,250.00	−2,250.00
–	–	–	–	–	–	–
−329.95	–	–	–	–	–	−992.31
–	−285.10	−556.35	–	–	–	−841.46
–	–	–	−141.08	−181.48	–	−322.57
–	–	–	–	–	–	–
20.07	–	–	–	–	–	66.71
–	108.34	246.66	24.82	26.13	–	405.95
19.82	–	–	206.39	227.95	–	491.48
–	–	–	–	–	–	–
–	–	−54.81	–	–	–	−54.81
−5.01	–	–	–	–	–	−9.68
–	–	–	–	–	–	–
−17.56	–	–	−13.06	−14.51	–	129.107
–	–	–	–	–	–	–
60.46	10.99	22.19	53.38	55.97	–	265.06
−25.09	–	–	–	–	–	−83.39
–	−28.51	−54.81	–	–	–	−83.32
–	–	–	−26.12	−29.03	–	−55.16
–	–	–	–	–	–	–

It is necessary to implement one further balancing procedure in order to obtain a complete resource balance that includes also the treatment processes. A complete technology matrix **X**, of dimensions $n \times n$, is defined:

$$\mathbf{X} = \begin{pmatrix} \tilde{\mathbf{Z}}_{I,I} & \mathbf{Z}_{I,II} \\ \tilde{\mathbf{Z}}_{II,I} & \mathbf{Z}_{II,II} \end{pmatrix} = \left(\begin{array}{ccccccc|c} 1{,}147.47 & 0 & 826.81 & -320.66 & 0 & 0 & 0 & 0 \\ 0 & 602.95 & 0 & -602.95 & 0 & 0 & 0 & 0 \\ 0 & 0 & 718.47 & 0 & -718.47 & 0 & 0 & 0 \\ 0 & 0 & 0 & 731.76 & 0 & -731.76 & 0 & 0 \\ 0 & 0 & 0 & 0 & 725.00 & 0 & -725.00 & 0 \\ 0 & 0 & 0 & 0 & 0 & 800.00 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 25{,}000.00 & 0 \\ -45.64 & -23.40 & -105.76 & -240.78 & -230.62 & -253.46 & 0 & -17.00 \end{array}\right) \quad (4.10)$$

It can be seen that **X** has been obtained by juxtaposing and stacking four known matrices. Indeed, $\tilde{\mathbf{Z}}_{II,I}$ has been obtained in Eq. 4.9; $\tilde{\mathbf{Z}}_{I,I}$ in Eq. 4.6. The latter corresponds to the upper left partition of Table 4.5. Instead $\mathbf{Z}_{I,II}$ and $\mathbf{Z}_{II,II}$ correspond to the whole upper right partition of Table 4.3. The following balancing condition must hold:

$$\mathbf{X} \cdot \mathbf{s}_{II} = \mathbf{y}_{I.} \quad (4.11)$$

where the $n \times n$ vector $\mathbf{y}_{II}$ amounts to the production plan shown in Table 4.4. Again, the scaling vector $\mathbf{s}_{II}$ is the unknown. The matrix equation can be solved as follows:

$$\mathbf{s}_{II} = \mathbf{X}^{-1} \cdot \mathbf{y}_{II} = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 52.92 \end{pmatrix}^{T} \quad (4.12)$$

It can be noted that, due to the above features of the numerical example, there is only one entry of $\mathbf{s}_{II}$ that is not equal to 1, and this corresponds to the treatment process. The final grid of balanced material flows concerning the main outputs of the system can then be obtained:

$$\tilde{\mathbf{X}} = \mathbf{X} \cdot \hat{\mathbf{s}}_{II} \quad (4.13)$$

The balancing operation above should be repeated also for the other resources involved in the treatment process. To do this, one further column must be added to matrix $[\mathbf{B}_{\bullet,I} \cdot \hat{\mathbf{s}}_I]$, as shown in Table 4.5, in order to include also the treatment process, the entries of which can be read in the last column of Table 4.2, or in partition $\mathbf{B}_{\bullet,II}$ of Table 4.3. Then, it can be post-multiplied by the diagonalised scaling vector $\hat{\mathbf{s}}_{II}$:

$$\tilde{\mathbf{B}} = \left(\mathbf{B}_{\bullet,I} \cdot \hat{\mathbf{s}}_I \mid \mathbf{B}_{\bullet,II} \right) \cdot \hat{\mathbf{s}}_{II} \quad (4.14)$$

The outcome of the overall balancing procedures described above is shown in Table 4.6.

Before closing this section, further aspects must be taken into account. In particular, the treatment processes also produce by-products which are their physical outputs, whereas their main outputs are the treatment services delivered to the other processes. These secondary products can be either recycled within the operations chain or disposed of externally. A more complicated situation would be that the by-products of a waste treatment undergo in turn further treatments. Indeed, Nakamura and Kondo (2009b) highlight that the waste treatment is a process of conversion of a given waste type into another waste type and then into some discharge into the environment. However, in the absence of a realistic and detailed description of the interactions among several treatment processes, in the numerical example the simplest situation has been considered where one treatment process E generates two by-products. One of them only requires a disposal service to be purchased from outside the system boundaries. Consequently, it has been recorded as a positive entry in matrix **R**. The waste type 4 is generated by E and it can be supplied to the production processes as a secondary input. The amount that is not recycled is disposed of externally.

The entries of Table 4.6 that refer to the amount of waste generated by the treatment processes have been denoted as $\tilde{\overline{\mathbf{N}}}_{II,\bullet}$, whereas the amount that is recycled by the production processes as $\underline{\tilde{\mathbf{N}}}_{II,\bullet}$. The row totals can be used to calculate again the recycling ratios concerning these types of waste, just as shown in Eq. 4.7 (though only for $k=4$). These ratios can be arranged as the entries of a column vector $\mathbf{r}_{II}$. In the example, there is only one waste type produced by the treatment processes, hence, the vector of recycling ratios is in fact a scalar: $\mathbf{r}_{II} = r = 0.14$. The amount that is not recycled is obtained as $(1-r) = 0.86$. The demand of externally purchased disposal services for the treatment process is:

$$(1-r)\cdot\tilde{\tilde{\overline{\mathbf{N}}}}_{II,\bullet} = \begin{pmatrix}0 & 0 & 0 & 0 & 0 & 0 & 0 & 754.67\end{pmatrix} \tag{4.15}$$

After the balancing operations have been carried out the mass balance contained in Table 4.6 should be modified, since the waste output produced by the production and treatment processes has been expressed as either the demand for internally provided treatment services or the demand for external disposal services. To this purpose, the rows of Table 4.6 that refer to the generation of waste must be multiplied by the recycling ratios making a distinction among those waste generated by the production processes and those generated by the treatment process. From a computational perspective, this task must be accomplished in two stages. First, the output of waste generated by the production processes is turned into the amount of waste which has been 'sold' as a secondary input to the other processes:

$$\hat{\mathbf{r}}_I\cdot\tilde{\tilde{\overline{\mathbf{N}}}}_{I,\bullet} = \hat{\mathbf{r}}_I\cdot\left(\overline{\mathbf{N}}_{I,I}\cdot\hat{\mathbf{s}}_I \mid \overline{\mathbf{N}}_{I,II}\right)\cdot\hat{\mathbf{s}}_{II} = \begin{pmatrix}38.32 & 16.49 & 0 & 0 & 0 & 0 & 0 & \mid & 0\\ 0 & 0 & 2.58 & 5.88 & 0.59 & 0.62 & 0 & \mid & 0\\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \mid & 0\end{pmatrix} \tag{4.16}$$

Then, the same procedure is applied to the waste generated by the treatment process:

$$\mathbf{r}_{II}\cdot\tilde{\tilde{\overline{\mathbf{N}}}}_{II,\bullet} = \mathbf{r}_{II}\cdot\left(\overline{\mathbf{N}}_{II,I}\cdot\hat{\mathbf{s}}_I \mid \overline{\mathbf{N}}_{II,II}\right)\cdot\hat{\mathbf{s}}_{II} = \begin{pmatrix}0 & 0 & 0 & 0 & 0 & 0 & 0 & \mid & 129.11\end{pmatrix} \tag{4.17}$$

Table 4.7 shows the overall balanced flows that characterise the manufacturing system considered.

Table 4.6 Input–output representation of the system

		Network node		Unit	*A*(1)	*A*(2)
		a(1)	Main output a(1)	t	1,147.47	–
	(I)	*a*(2)	Main output a(2)	t	–	602.95
	(I)	*b*(1)	Main output b(1)	t	–	–
$\tilde{\mathbf{X}}$	(I)	*b*(2)	Main output b(2)	t	–	–
	(I)	*c*(1)	Main output c(1)	t	–	–
	(I)	*c*(2)	Main output c(2)	t	–	–
	(I)	*d*	Main output c(1) – used	m^2	–	–
	(II)	*e*	Waste treatment	t	−45.64	−23.40
		1	Raw material 1	t	−419.81	−250.91
		2	Raw material 2	t	−489.77	−268.98
		3	Raw material 3	t	–	–
		4(1)	Water (firm 1)	m^3	−233.23	−100.37
		3	Water (Firm 2)	m^3	–	–
		4(1)	Fossil fuel (firm 1)	m^3	−32,185.08	−31,364.37
		4(2)	Fossil fuel (firm 2)	m^3	–	–
		4(1)	Electric energy (firm 1)	MWh	−76.96	−47.67
		5	Electric energy (firm 2)	MWh	–	–
		6	Maintenance materials (use stage)	L	–	–
		7	Treatment raw materials	t	–	–
			Cycle time A	t	−662.36	−329.95
			Cycle time B	t	–	–
			Cycle time C	t	–	–
			Cycle time E	t	–	–
$\tilde{\mathbf{B}}$	$\tilde{\tilde{\mathbf{N}}}_{I,\bullet}$		Waste type 1 (out)	t	46.64	20.07
	$\tilde{\tilde{\mathbf{N}}}_{I,\bullet}$		Waste type 2 (out)	t	–	–
	$\tilde{\tilde{\mathbf{N}}}_{I,\bullet}$		Waste type 3 (out)	t	37.31	19.82
	$\tilde{\tilde{\mathbf{N}}}_{II,\bullet}$		Waste type 4 (out)	t	–	–
	$\tilde{\tilde{\mathbf{N}}}_{I,\bullet}$	8	Waste type 1 (in)	t	–	–
	$\tilde{\tilde{\mathbf{N}}}_{I,\bullet}$	9	Waste type 2 (in)	t	−4.66	−5.01
	$\tilde{\tilde{\mathbf{N}}}_{I,\bullet}$	10	Waste type 3 (in)	t	–	–
	$\tilde{\tilde{\mathbf{N}}}_{II,\bullet}$	11	Waste type 4 (in)	t	−83.96	−17.56
		12	External waste disposal (sewage)	t	–	–
		12	External waste disposal (solid)	t	–	–
		13	CO_2 emissions	t	62.04	60.46
			Capacity A	%	−58.30	−25.09
			Capacity B	%	–	–
			Capacity C	%	–	–
			Capacity E	%	–	–

Included treatment process. Flows balanced

Processes						
(I)					(II)	
B(1)	*B*(2)	*C*(1)	*C*(2)	*D*	*E*	Totals
−826.81	−320.66	–	–	–	–	–
–	−602.95	–	–	–	–	–
718.47	–	−718.47	–	–	–	–
–	731.76	–	−731.76	–	–	–
–	–	725.00	–	−725.00	–	–
–	–	–	800.00	–	–	800.00
–	–	–	–	25,000.00	–	25,000.00
−105.76	−240.78	−230.62	−253.46	–	899.66	–
–	–	–	–	–	–	−670.72
–	–	–	–	–	–	−758.75
–	–	−35.27	−133.58	–	–	−168.84
–	–	–	–	–	–	−333.59
–	–	−189.41	−174.22	–	–	−363.64
–	–	–	–	–	–	−63,549.45
−5,702.13	−11,510.13	−27,693.69	−29,038.11	–	–	−73,944.77
–	–	–	–	–	–	−124.64
−19.95	−36.17	−6.53	−11.61	–	−202.16	−276.44
–	–	–	–	−2,250.00	–	−2,250.00
–	–	–	–	–	−26.46	−26.46
–	–	–	–	–	–	−992.31
−285.10	−556.35	–	–	–	–	−841.46
–	–	−141.08	−181.48	–	–	−322.57
–	–	–	–	–	−687.97	−687.97
–	–	–	–	–	–	66.71
108.34	246.66	24.82	26.13	–	–	405.95
–	–	206.39	227.95	–	–	491.48
–	–	–	–	–	883.78	883.78
–	−54.81	–	–	–	–	−54.81
–	–	–	–	–	–	−9.68
–	–	–	–	–	–	–
–	–	−13.06	−14.51	–	–	129.107
–	–	–	–	–	–	–
–	–	–	–	–	–	−15.87
10.99	22.19	53.38	55.97	–	–	265.06
–	–	–	–	–	–	−83.39
−28.51	−54.81	–	–	–	–	−83.32
–	–	−26.12	−29.03	–	–	−55.16
–	–	–	–	–	−79.38	−79.38

Table 4.7 Input–output representation of the system

		Network node		Unit	$A(1)$	$A(2)$
$\tilde{\mathbf{X}}$	(I)	$a(1)$	Main output a(1)	t	1,147.47	–
		$a(2)$	Main output a(2)	t	–	602.95
		$b(1)$	Main output b(1)	t	–	–
		$b(2)$	Main output b(2)	t	–	–
		$c(1)$	Main output c(1)	t	–	–
		$c(2)$	Main output c(2)	t	–	–
		d	Main output c(1) – used	m^2	–	–
	(II)	e	Waste treatment	t	−45.64	−23.40
$\tilde{\mathbf{B}}$		1	Raw material 1	t	−419.81	−250.91
		2	Raw material 2	t	−489.77	−268.98
		3	Raw material 3	t	–	–
		4(1)	Water (firm 1)	m^3	−233.23	−100.37
		3	Water (firm 2)	m^3	–	–
		4(1)	Fossil fuel (firm 1)	m^3	−32,185.08	−31,364.37
		4(2)	Fossil fuel (firm 2)	m^3	–	–
		4(1)	Electric energy (firm 1)	MWh	−76.96	−47.67
		5	Electric energy (firm 2)	MWh	–	–
		6	Maintenance materials (use stage)	L	–	–
		7	Treatment raw materials	t	–	–
			Cycle time A	t	−662.36	−329.95
			Cycle time B	t	–	–
			Cycle time C	t	–	–
			Cycle time E	t	–	–
			Waste type 1 (sale of waste)	t	38.32	16.49
			Waste type 2 (sale of waste)	t	–	–
			Waste type 3 (sale of waste)	t	–	–
			Waste type 4 (sale of waste)	t	–	–
		8	Waste type 1 (in)	t	–	–
		9	Waste type 2 (in)	t	−4.66	−5.01
		10	Waste type 3 (in)	t	–	–
		11	Waste type 4 (in)	t	−83.96	−17.56
		12	External waste disposal (II)	t	–	–
		12	External waste disposal (I)	t	–	–
		13	CO_2 emissions	t	62.04	60.46
			Capacity A	%	−58.30	−25.09
			Capacity B	%	–	–
			Capacity C	%	–	–
			Capacity E	%	–	–

Flows balanced. Including *Sale of waste*

Processes						
(I)					(II)	
B(1)	*B*(2)	*C*(1)	*C*(2)	*D*	*E*	Totals
−826.81	−320.66	–	–	–	–	–
–	−602.95	–	–	–	–	–
718.47	–	−718.47	–	–	–	–
–	731.76	–	−731.76	–	–	–
–	–	725.00	–	−725.00	–	–
–	–	–	800.00	–	–	800.00
–	–	–	–	25,000.00	–	25,000.00
−105.76	−240.78	−230.62	−253.46	–	899.66	–
–	–	–	–	–	–	−670.72
–	–	–	–	–	–	−758.75
–	–	−35.27	−133.58	–	–	−168.84
–	–	–	–	–	–	−333.59
–	–	−189.41	−174.22	–	–	−363.64
–	–	–	–	–	–	−63,549.45
−5,702.13	−11,510.13	−27,693.69	−29,038.11	–	–	−73,944.77
–	–	–	–	–	–	−124.64
−19.95	−36.17	−6.53	−11.61	–	−202.16	−276.44
–	–	–	–	−2,250.00	–	−2,250.00
–	–	–	–	–	−26.46	−26.46
–	–	–	–	–	–	−992.31
−285.10	−556.35	–	–	–	–	−841.46
–	–	−141.08	−181.48	–	–	−322.57
–	–	–	–	–	−687.97	−687.97
–	–	–	–	–	–	54.81
2.58	5.88	0.59	0.62	–	–	9.68
–	–	–	–	–	–	–
–	–	–	–	–	129.11	129.11
–	−54.81	–	–	–	–	−54.81
–	–	–	–	–	–	−9.68
–	–	–	–	–	–	–
–	–	−13.06	−14.51	–	–	129.11
–	–	–	–	–	754.67	754.67
–	–	–	–	–	15.87	15.87
10.99	22.19	53.38	55.97	–	–	265.06
–	–	–	–	–	–	−83.39
−28.51	−54.81	–	–	–	–	−83.32
–	–	−26.12	−29.03	–	–	−55.16
–	–	–	–	–	−79.38	−79.38

3.5 Process Inefficiencies and Allocation

In this section, the computational structure described so far will be further extended in order to take more accurately into account elements that are of particular concern for the manufacturing firms: the management of scrap/by-products and the management of the beginning and final inventories.

For each process the requirements of raw materials and other resources are those specified in the bill of materials (BOM). However, due to scrap and spoilage the entries of Tables 4.1 and 4.2 which record the process inputs may be different from the specifications found in the BOM. In particular, the efficiency of the conversion of inputs into outputs is determined by several factors: moisture content of some raw materials or the amount of input that is going to be turned into waste during the conversion process expressed as the expected scrap or spoilage percentage.

Consider, for example, the amount of raw material 1 that is required by process *A*. Assume that m_{11} records such input requirement as specified by the BOM. If $0<\eta<1$ is the conversion efficiency, then the amount of raw material 1 that should be recorded in partition **M** of Table 4.2 is:

$$m_{11} = \frac{m_{11}^{*}}{1-\eta}$$

The conversion inefficiency can be quantified as $m_{11} - m_{11}{}^{*}$. One convention of the proposed model is that such scrap and by-products must be recorded as the entries of matrix $\bar{\mathbf{N}}$ or **R** in Table 4.2. Two categories of costs can be associated with them (Jasch 2003): (i) the value of the resources that have been used to produce such secondary outputs jointly with the main products; and (ii) the cost of treatment or disposal processes they possibly undergo, either provided internally or purchased externally. As to point (i) consider, for example, process *B*(1). While it produces 5.04 ton of intermediate product *b*(1), after a process run that takes 2 h, it also generates 0.76 t of scrap, called waste type 2. In order to assess the cost of producing this scrap, *joint product costing* can be applied (Hansen and Mowen 2003). To do this, the physical inventory in Table 4.2 must be reformulated.

In particular, an *allocation* procedure should be preliminarily carried out, which is similar to that commonly used within the computational structure of LCA (Heijungs and Suh 2002). Process *B*(1) is split into two independent unit processes: *B*(1) and *B(scrap)*. The former produces the same main product as before, that is commodity *b*(1) though no longer producing the scrap. Process *B(scrap)* is a fictitious one that is assumed to produce the former by-product as its main output. This is used to give evidence to the value of resources that have been used to produce such scrap. All the entries of matrix **A** (Table 4.3) that refer to *B*(1) can be assigned, by allocation, to *B*(1) and *B(scrap)* according to a parameter which is called the allocation factor λ. It can be established according to several criteria since the allocation is a subjective procedure. Assume the resources are assigned pr oportionally to the mass of scrap to process *B(scrap)* and proportionally to the mass of main product *b*(1) to process *B*(1). It follows that $\lambda = 0.87$ and $(1-\lambda) = 0.13$. The outcome of the allocation procedure is shown in Table 4.8 (that can be seen as a reformulation of Table 4.3 from which it differs because of an additional row and column that correspond to the scrap).

It is important, for cost assignment purposes, that each process that requires the main product *b*(1), also requires - though not physically - the by-products the latter generates. Otherwise, the process' inefficiencies would be artfully eliminated. Furthermore, it should be noted that within the column of Table 4.8 corresponding to process *B(scrap)* the same flow has been recorded twice, both as a main output and as a by-product exactly as before. This accounting contrivance allows the cost of treating the scraps to be entirely assigned to the fictitious process producing them. Unlike allocation in LCA, this operation is meant to facilitate cost assignment, interfering with the mass balance that holds column-wise within Table 4.3.

As a consequence of the reformulation of Table 4.3 into Table 4.8, a row that corresponds to the scrap must be added to the vector of final deliveries $\mathbf{y}_I$ used in Eq. 4.4. Moreover, in order to complete the production plan, the beginning and final inventory can be introduced. Table 4.9 provides a reformulation of the previous production plan (Table 4.4) with an additional information: the beginning inventory of commodity *a*(1).

In the example, the amount of output produced by process *A*(1) will be less than the amount that would have been produced in absence of a beginning inventory of commodity *a*(1) to meet the production plan (last column in Table 4.9).

The balancing operations that have been illustrated in Sect. 4.3.4 must be simply carried out while making reference, within the formulae, to the entries of Table 4.8 and Table 4.9 that correspond to the matrix notation. The scaling vector $\mathbf{s}_I$ that explicitly takes into account the production of scrap and the beginning inventory of commodity *a*(1) now reads:

$$\mathbf{s}_I = \mathbf{Z}_{I,I}^{-1} \cdot \mathbf{y}_I = \begin{pmatrix} 0.0203 & 0 & 0.0203 & 0.0203 & 0.0089 & 0.0231 & 0.0081 & 0.0006 \\ 0 & 0.0208 & 0 & 0 & 0.0171 & 0 & 0.0157 & 0 \\ 0 & 0 & 0.1984 & 0 & 0 & 0.1966 & 0 & 0.0057 \\ 0 & 0 & 0 & 1.3157 & 0 & 0.1966 & 0 & 0.0057 \\ 0 & 0 & 0 & 0 & 0.3745 & 0 & 0.3426 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.1802 & 0 & 0.0052 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.01815 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.0100 \end{pmatrix} \cdot \begin{pmatrix} -200 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 800 \\ 25{,}000 \end{pmatrix} = \begin{pmatrix} 19.25 \\ 12.54 \\ 142.55 \\ 142.55 \\ 274.06 \\ 130.63 \\ 145.19 \\ 250.00 \end{pmatrix} \qquad (4.18)$$

A comprehensive balance of the resources used and generated by the manufacturing system considered is shown in Table 4.10.

It has been obtained by carrying out all the previously formalised operations using the reformulated matrices. Table 4.10 also records the cost coefficients that will be used in the next section.

Table 4.8 Input–output representation of the system, with allocation

		Network node		Unit
$\begin{bmatrix} \mathbf{Z}_{I,I} & \mathbf{Z}_{I,II} \\ \mathbf{Z}_{II,I} & \mathbf{Z}_{II,II} \end{bmatrix}$	(I)	*a*(1)	Main output a(1)	t
		a(2)	Main output a(2)	t
		b(1)	Main output b(1)	t
			Main output b(scrap)	t
		b(2)	Main output b(2)	t
		c(1)	Main output c(1)	t
		c(2)	Main output c(2)	t
		d	Main output c(1) – used	m^2
	(II)	*e*	Waste treatment	t
$\begin{bmatrix} \mathbf{B}_{\bullet,I} & \mathbf{B}_{\bullet,II} \end{bmatrix}$	$\begin{bmatrix} -\mathbf{M}_{\bullet,I} & -\mathbf{M}_{\bullet,II} \end{bmatrix}$	1	Raw material 1	t
		2	Raw material 2	t
		3	Raw material 3	t
		4(1)	Water (firm 1)	m^3
		3	Water (firm 2)	m^3
		4(1)	Fossil fuel (firm 1)	m^3
		4(2)	Fossil fuel (firm 2)	m^3
		4(1)	Electric energy (firm 1)	MWh
		5	Electric energy (firm 2)	MWh
		6	Maintenance materials (use stage)	L
		7	Treatment raw materials	t
	$\begin{bmatrix} -\mathbf{H}_{\bullet,I} & -\mathbf{H}_{\bullet,II} \end{bmatrix}$		Cycle time A	t
			Cycle time B	t
			Cycle time C	t
			Cycle time E	t
	$\begin{bmatrix} \overline{\mathbf{N}}_{I,I} & \overline{\mathbf{N}}_{I,II} \end{bmatrix}$		Waste type 1 (out)	t
			Waste type 2 (out)	t
			Waste type 3 (out)	t
	$\begin{bmatrix} \overline{\mathbf{N}}_{II,I} & \overline{\mathbf{N}}_{II,II} \end{bmatrix}$		Waste type 4 (out)	t
	$\begin{bmatrix} -\underline{\mathbf{N}}_{I,I} & -\underline{\mathbf{N}}_{I,II} \end{bmatrix}$	8	Waste type 1 (in)	t
		9	Waste type 2 (in)	t
		10	Waste type 3 (in)	t
	$\begin{bmatrix} -\underline{\mathbf{N}}_{II,I} & -\underline{\mathbf{N}}_{II,II} \end{bmatrix}$	11	Waste type 4 (in)	t
	$\begin{bmatrix} \mathbf{R}_{\bullet,I} & \mathbf{R}_{\bullet,II} \end{bmatrix}$	12	External waste disposal	t
		13	CO_2 emissions	t
	$\begin{bmatrix} -\mathbf{C}_{\bullet,I} & -\mathbf{C}_{\bullet,II} \end{bmatrix}$		Capacity A	%
			Capacity B	%
			Capacity C	%
			Capacity E	%

Flows not balanced

Processes								
(I)								(II)
A(1)	*A*(2)	*B*(1)	*B(scrap)*	*B*(2)	*C*(1)	*C*(2)	*D*	*E*
49.20	–	−5.04	−0.76	−1.17	–	–	–	–
–	48.06	–	–	−2.20	–	–	–	–
–	–	5.04	–	–	−5.50	–	–	–
–	–	–	0.76	–	−0.83	–	–	–
–	–	–	–	2.67	–	−5.04	–	–
–	–	–	–	–	5.55	–	2.09	–
–	–	–	–	–	–	5.51	–	–
–	–	–	–	–	–	–	100.00	–
–	–	–	–	–	–	–	–	17.00
−18.00	−20.00	–	–	–	–	–	–	–
−21.00	−21.44	–	–	–	–	–	–	–
–	–	–	–	–	−0.27	−0.92	–	–
−10.00	−8.00	–	–	–	–	–	–	–
–	–	–	–	–	−1.45	−1.2	–	–
−1,380.00	−2,500.00	–	–	–	–	–	–	–
–	–	−34.76	−5.24	−42.00	−212.00	−200.00	–	–
−3.30	−3.80	–	–	–	–	–	–	–
–	–	−0.12	−0.02	−0.132	−0.05	−0.08	–	−3.82
–	–	–	–	–	–	–	−9.00	–
–	–	–	–	–	–	–	–	−0.50
−28.40	−26.30	–	–	–	–	–	–	–
–	–	−1.74	−0.26	−2.03	–	–	–	–
–	–	–	–	–	−1.08	−1.25	–	
–	–	–	–	–	–	–	–	−13.00
2.00	1.60	–	–	–	–	–	–	–
–	–	–	0.76	0.09	0.19	0.18	–	–
1.60	1.58	–	–	–	1.58	1.57	–	–
–	–	–	–	–	–	–	–	16.70
–	–	–	–	−0.20	–	–	–	–
−0.20	−0.40	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–
−3.60	−1.40	–	–	–	−0.10	−0.10	–	–
–	–	–	–	–	–	–	0.30	–
2.66	4.81	0.067	0.010	0.08	0.408	0.385	–	–
−2.50	−2.00	–	–	–	–	–	–	–
–	–	−0.17	−0.03	−0.20	–	–	–	–
–	–	–	–	–	−0.20	−0.20	–	–
–	–	–	–	–	–	–	–	−3.00

Table 4.9 Production plan with inventories and scrap

			Unit	Plan's elements: Beginning inventory (−)	Production plan (+)	Final inventory (+)	Reference flow (y_i)
(I)	$a(1)$	Main output a(1)	t	−200.00	–	–	−500.00
(I)	$a(2)$	Main output a(2)	t	–	–	–	–
(I)	$b(1)$	Main output b(1)	t	–	–	–	–
(I)		Main output b(scrap)	t	–	–	–	–
(I)	$b(2)$	Main output b(2)	t	–	–	–	–
(I)	$c(1)$	Main output c(1)	t	–	–	–	–
(I)	$c(2)$	Main output c(2)	t	–	800.00	–	800.00
(I)	d	Main output c(1) – used	m^2	–	25,000.00	–	25,000.00
(II)	e	Waste treatment	t	–	–	–	–

4 Process and Product Cost Assessment

4.1 Linking the Quantity Model to the Cost Model

In the previous sections the comprehensive balance of the resources used and generated by the manufacturing system during a certain planning period has been modelled. In order to assess the process and product cost these relationships among the production processes must be turned into financial transactions. On the one hand, those cost drivers that vary according to the activity levels of processes have been quantified so that the direct materials costs can be traced and the conversion costs, that is labour, depreciation and production overheads, can be assigned to each process. On the other hand, processes also consume resources which do not vary according to their activity levels. Examples would be the ancillary materials, the fixed overheads, the equipment maintenance, the indirect labour, and the administrative authorisations to store hazardous substances. Consequently, the entity of these resources can be estimated more accurately with reference to the planning period than with reference to the base activity level of each process.

Thus, the variable cost drivers considered so far must be integrated with other factors which are independent from the activity levels of processes. These period-related cost drivers, which are not necessarily physical ones, must be recorded in a separate matrix **F** as shown in Table 4.11. They will be considered only after the balancing of variable resources against the production plan has been carried out.

For the sake of completeness the allocation factors have been applied to the entries of Table 4.11 (see Sect. 4.3.5) and then shown at the bottom of Table 4.10. It should be noted that the above might also serve the purpose of taking into account, within the computational procedure, three distinct supply chain cost levels: direct costs, activity-based costs and transaction costs (Seuring 2002).

The assessment of costs is carried out in two steps. In the first step monetary values are applied to the resources recorded in matrix $\widetilde{\mathbf{B}}$ (see Table 4.10) thus obtaining the direct process costs. In the second step the unit manufacturing cost of each intermediate and final product is assessed. In particular, the mechanism that allows the application of monetary values to the physical flows recorded in $\widetilde{\mathbf{X}}$ (see Table 4.10) is the formalised equivalent of *process costing*. The input–output technological model described so far, is structured so that the main output of a process is *transferred* into the downstream processes as a separate category of direct materials at its manufacturing cost.

4.2 Direct Process Costs

As to the first step, it is necessary to define the standard unit costs of the externally purchased inputs as well as the *predetermined* overhead cost rates that will be applied to the processes according to the appropriate cost drivers, for example the cycle time expressed in terms of machine hours. These values have been expressed as €/unit and recorded in the last column of Table 4.10 where the equivalent matrix notations have been shown. Some cost items will be discussed below.

1. An estimate of the predetermined overhead cost rates for each process can be obtained, as usual, dividing the expected annual amount of overhead costs (excluding the fixed ones), *E(C)*, by the expected annual amount of machine hours, that have been chosen as a cost driver, *E(h)* (where *E* means 'expected') and then applied throughout the year. In the example, a different overhead cost rate has been determined for each plant (corresponding to entries 12 to 15 of vector $\mathbf{p}_M$ in Table 4.10):

$$(\mathbf{p}_M)_k = \frac{E(C)_k}{E(h)_k}$$

   where ($k = 12 \ldots 15$). The above may also hold for the period-related fixed resources. For example, the expected cost of the plant maintenance is divided by the expected number of maintenance interventions during the year. An alternative method that has been used here, is that of estimating the expected cost for the planning period (1 month) and then multiplying the whole amount by a percentage that has been established for each process. This is the case, in the numerical example, of the fixed component of the electric energy cost.
2. As to the use stage, the unit cost of product maintenance materials has been calculated as the present value of an annually recurring uniform amount of, say 10€/L, for 40 years, at 5%. This amount will be multiplied times the corresponding annual quantities that have been recorded in Table 4.10 column *D*.
3. The estimated cost coefficient of the carbon dioxide (CO_2) emissions can be read as the second element of vector $\mathbf{p}_R$ in Table 4.10. It has been assumed that Firm 1 and Firm 2 purchase the emission allowances as if they were a single entity.

Table 4.10 Input–output representation of the system, with allocation

	Grid of balanced physical flows			(I)		
				A		
	Network node		Unit	(1)	(2)	(1)
	a(1)	Main product a(1)	t	947.47	–	−718.46
	a(2)	Main product a(2)	t	–	602.94	–
	b(1)	Main product b(1)	t	–	–	718.47
		Scrap	t	–	–	–
X	*b*(2)	Main product b(2)	t	–	–	–
	c(1)	Main product c(1)	t	–	–	–
	c(2)	Main product c(2)	t	–	–	–
	c	Main product b(1) (used)	m^2	–	–	–
	d	Treatment	t	−33.29	−21.11	–
	1	Raw material 1	t	−346.63	−250.91	–
	2	Raw material 2	t	−404.41	−268.98	–
	3	Raw material 3	t	–	–	–
	4(A)	Water (firm 1)	m^3	−192.57	−100.36	–
	3	Water (firm 2)	m^3	–	–	–
	4	Fossil Fuels (firm 1)	m^3	−26,575.32	−31,364.37	–
	4	Fossil Fuels (firm 2)	m^3	–	–	−4,954.95
	5	Electric energy (firm 1)	MWh	−63.54	−47.67	–
	5	Electric energy (firm 2)	MWh	–	–	−17.34
	6	Maintenance materials	L	–	–	–
	7	Treatment materials	t	–	–	–
		Cycle time *A*	h	−546.91	−329.95	–
		Cycle time *B*	h	–	–	−247.74
		Cycle time *C*	h	–	–	–
B		Cycle time *E*	h	–	–	–
		Waste type 1 (*sale*)	t	36.03	18.78	–
		Waste type 2 (*sale*)	t	–	–	–
		Waste type 3 (*sale*)	t	–	–	–
		Waste type 4 (*sale*)	t	–	–	–
	8	Waste type 1 (*input*)	t	–	–	–
	9	Waste type 2 (*input*)	t	−3.85	−5.02	–
	10	Waste type 3 (*input*)	t	–	–	–
	11	Waste type 4 (*input*)	t	−69.32	−17.56	–
	12	External disposal (treatment)	t	–	–	–
	12	External disposal (production)	t	–	–	–
	13	CO_2	t	51.23	60.46	9.55
		Capacity *A*	%	−48.14	−25.09	–
		Capacity *B*	%	–	–	−24.77
		Capacity *C*	%	–	–	–
		Capacity *E*	%	–	–	–
		Equipment maintenance	Number of interventions	−1.00	−1.00	−1.74
		Fixed cost of energy (firm 1)	%	−50.00	−50.00	–
F		Fixed cost of energy (firm 2)	%	–	–	−13.03
		Indirect labour (firm 1)	%	−65.00	−35.00	–
		Indirect labour (firm 2)	%	–	–	−34.75

Flows balanced

Processes							Cost coefficients	
					(II)			
B		*C*		*D*	*E*			
(*scrap*)	(2)	(1)	(2)			Totals	€/unit	
−108.34	−320.66	–	–	–	–	−200.00	p_1	
–	−602.94	–	–	–	–	–	p_2	
–	–	−718.47	–	–	–	–	p_3	
108.34	–	−108.34	–	–	–	–	p_4	
–	731.76	–	−731.76	–	–	–	p_5	p
–	–	725.00	–	−725.00	–	–	p_6	
–	–	–	800.00	–	–	800.00	p_7	
–	–	–	–	25.000	–	25.000	p_8	
−105.97	−241.27	−230.67	−253.51	–	885.84	–	p_9	
–	–	–	–	–	–	−597.54	×−70	
–	–	–	–	–	–	−673.38	×−30	
–	–	−32.27	−133.57	–	–	−168.84	×−300	
–	–	–	–	–	–	−292.94	×−0.05	
–	–	−189.41	−174.23	–	–	−363.64	×−0.04	
–	–	–	–	–	–	−57,939.69	×−0.40	
−747.17	−11,510.83	−27,693.69	−29,038.11	–	–	−73,944.77	×−0.35	
–	–	–	–	–	–	−111.22	×−5.6	p_M
−2.61	−36.17	−6.53	−11.61	–	−199.053	−273.33	×−4.0	
–	–	–	–	−2,250.00	–	−2.250	×−17.16	
–	–	–	–	–	−26.05	−26.05	×−80.00	
–	–	–	–	–	–	−876.86	×−0.12	
−37.36	−556.36	–	–	–	–	−841.46	×−0.57	
–	–	−141.08	−181.49	–	–	−322.57	×−1.2	
–	–	–	–	–	−677.41	−677.41	×−0.7	
–	–	–	–	–	–	54.81	×−0.5	
2.37	5.39	0.54	0.57	–	–	8.86	×−0.2	
–	–	–	–	–	–	–	×−0.7	$\overline{p}$
–	–	–	–	–	114.47	114.47	×−0.4	
–	−54.81	–	–	–	–	−54.81	×−0.5	
–	–	–	–	–	–	−8.87	×−0.2	
–	–	–	–	–	–	–	×−0.7	$\overline{p}$
–	–	−13.06	−14.52	–	–	−114.47	×−0.4	
–	–	–	–	–	755.73	755.73	×25	
–	–	–	–	–	15.63	15.63	×30	p_R
1.44	22.19	53.38	55.97	–	–	254.24	×17	
–	–	–	–	–	–	−73.23	×0	
−3.73	−54.81	–	–	–	–	−83.32	×0	
–	–	−26.12	−29.03	–	–	−55.16	×0	p_C
–	–	–	–	–	−78.16	−78.16	×0	
−0.26	−3.00	–	–	–	–	−7.00	×−250	
–	–	–	–	–	–	−100.00	×−70	p_F
−1.97	−20.00	−25.00	−30.00	–	−10.00	−100.00	×−110	
–	–	–	–	–	–	−100.00	×−370	
−5.24	−15.00	–	−5.00	−25.00	−15.00	−100.00	×−500	

Table 4.11 Period cost drivers

Matrix **F**		Processes								
		(I)							(II)	
	Unit	*A*(1)	*A*(2)	*B*(1)	*B*(2)	*C*(1)	*C*(2)	*D*	*E*	(Totals)
Equipment maintenance	Number of interventions	−1.00	−1.00	−2.00	−3.00	–	–	–	–	−7.00
Fixed cost of energy (firm 1)	%	−50.00	−50.00	–	–	–	–	–	–	−100.00
Fixed cost of energy (firm 2)	%	–	–	−15.00	−20.00	−25.00	−30.00	–	−10.00	−100.00
Indirect labour (firm 1)	%	−65.00	−35.00	–	–	–	–	–	–	−100.00
Indirect labour (firm 2)	%	–	–	−40.00	−15.00	–	−5.00	−25.00	−15.00	−100.00

In the same way are assigned some allowances at the beginning of each year. Let p^* be the cost estimate. It can be obtained dividing the expected cost of purchasing emission allowances by the expected CO_2 emissions generated by the system during the year, called q. The purchasing cost must be net of the government grant consisting in the initial allocation of allowances free of charge and expressed in physical amounts as q^*. Because of the *cap and trade* mechanism, p^* should not be a figure but rather a function like:

$$\begin{cases} p^* = 17\text{€/ton} & \text{if } q > q^* \\ p^* = 0 & \text{if} q \leq q^* \end{cases} \tag{4.19}$$

4. A cost function which is similar to the above should be adopted in order to assess the cost of using raw materials that have been purchased in different periods of time at a different cost. Assuming that the beginning inventory of a certain raw material amounts to $q^{(0)}$ the unit cost of such inventory is $p^{(0)}$. If $q^{(*)}$ is the planned consumption of that resource as it can be read from Table 4.10 and $p^{(1)}$ is the expected unit purchase price that will be applied to that commodity during the planning period, then the cost $p^{(*)}$ that should be applied is a function like:

$$\begin{cases} p^* = p^{(0)}\text{€/ton} & \text{if } 0 < q < q^{(0)} \\ p^* = p^{(1)}\text{€/ton} & \text{if } q^{(0)} < q < q^* \end{cases} \tag{4.20}$$

5. Within the supply chain considered, a waste will be *sold* – and, consequently, purchased – at an exogenous price $\overline{\mathbf{p}}$. This follows the model proposed by Nakamura and Kondo (2006b). If, for a waste type k, $(\overline{\mathbf{p}})_k < 0$ then such price is an income for the process selling the waste and a cost for the process purchasing it as a secondary input (see Table 4.10). However, it may also happen that $(\overline{\mathbf{p}})_k \geq 0$ when the process that generates the waste respectively pays another process to use the waste as a secondary input, or receives no money for the sale of the waste. Whatever the case, these transactions sum up to zero if the entire operations chain is taken into account as a whole. It should be pointed out that the price of waste is not its manufacturing cost. Indeed, the conventions explained in Sect. 4.3.5 are such that the cost of producing a waste or scrap is transferred into the processes that requir e the main output the production of which generates the scrap. This reflects the cause-effect relationships.
6. One last remark concerns the beginning inventory of one main product, namely commodity $b(1)$, as shown in Table 4.9. For the cost to be assessed properly it is indeed necessary to subtract the amount of such initial inventory from the overall amount of the same commodity that is required as an input by the processes. In the numerical example, to accomplish this task one should modify the first row of Table 4.10 and add one further row to the same table in order to account for the beginning inventory as shown in Table 4.12.

Table 4.12 Changes to be made to Table 4.10 due to the beginning inventory

		(I)								(II)	
		A		*B*			*C*		*D*	*E*	
	Unit	(1)	(2)	(1)	*scrap*	(2)	(1)	(2)			€/unit
Main product a(1)	t	947.47	0	−618.47	−108.34	−220.00	–	–	–	–	$\times p_1$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Beginning inventory	t	–	–	−100.00	–	−100.00	–	–	–	–	$\times p_S$

With reference to Table 4.12, it has been assumed that the beginning inventory of commodity $a(1)$, that amounts to 100 ton has been used 50% in process $B(1)$ and 50% in process $B(2)$. These amounts have been subtracted from the corresponding entries of the first row of Table 4.10 and moved to a row that has been added to take such inventories into account. A cost coefficient should be associated with the beginning inventory: $p_S = -20$ €/ton (the sign is consistent with the one of the cost coefficients in Table 4.10).

Finally, the vector of cost coefficients reads:

$$\mathbf{p}_B^T = \begin{bmatrix} \mathbf{p}_M & \overline{\mathbf{p}} & \overline{\mathbf{p}} & \mathbf{p}_R & \mathbf{p}_C & \mathbf{p}_F & p_S \end{bmatrix}$$

where superscript T means that the vector has been transposed. Making reference to the notation in Table 4.10, taken as modified by Table 4.12, direct process cost can be determined as follows:

$$\mathbf{p}_B^T \cdot \tilde{\mathbf{B}} = \omega \tag{4.21}$$

This yields the following figures:

$$\boldsymbol{\omega} = (76{,}139.3 \quad 56{,}217.3 \quad 23{,}354.7 \quad 3{,}219.7 \quad 17{,}344.19 \quad 24{,}139.6 \quad 57{,}264.5 \quad 51{,}107.9 \quad | \quad 31{,}271.3)$$

where each element is expressed in monetary terms. For example, €76,139.3 is the total cost of process $A(1)$. This includes, for a given planning period (1 month), such cost elements as (a) direct material costs, (b) conversion costs included the fixed overheads, (c) beginning inventory costs, and (d) costs (revenues) due to the recycling (or sale) of wastes.

4.3 Unit Product Cost

Once the direct cost of each process has been determined, it is possible to calculate the unit cost of each intermediate and final product. To do this, the interdependences among processes must be taken into account, as modelled in the previous sections. Indeed, within the input–output technological model described so far the total cost of producing the main output of a given process is assumed to equal the cost of the inputs transferred in from the other processes, including the treatment ones, in addition to the direct costs incurred (vector ω). The inputs from the other processes are transferred in at their manufacturing cost. In this way, the entire operation chains is seen as a vertically integrated divisionalised business, where transfer prices based upon the manufacturing costs are charged for the transactions among divisions. This approach can help addressing, in a formal way, the consolidated network as an entity when analysing its profitability as a whole (Paranko et al. 2005).

A system of simultaneous linear equations can be formulated, and corresponds to the economic counterpart of the one in Eq. 4.3

$$\left\{\begin{array}{llllllll}
 & & & & 33.29\cdot p_9 & +\ 76{,}139.3 & = & 947.47\cdot p_1 \\
 & & & & 21.11\cdot p_9 & +\ 56{,}217.3 & = & 602.94\cdot p_2 \\
718.46\cdot p_1 & & & & & +\ 23{,}354.7 & = & 718.47\cdot p_3 \\
108.34\cdot p_1 & & & & +105.97\cdot p_9 & +\ 3{,}219.7 & = & 108.34\cdot p_4 \\
320.66\cdot p_1 & +602.94\cdot p_2 & & & +241.27\cdot p_9 & +\ 17{,}344.19 & = & 731.76\cdot p_5 \\
 & & 718.47\cdot p_3 & +108.34\cdot p_4 & +230.67\cdot p_9 & +\ 24{,}139.6 & = & 725.00\cdot p_6 \\
 & & & 731.76\cdot p_5 & +253.51\cdot p_9 & +\ 57{,}264.5 & = & 800.00\cdot p_7 \\
 & & & 731.76\cdot p_6 & & +\ 51{,}107.9 & = & 25{,}000.00\cdot p_8 \\
 & & & & & +\ 31{,}271.3 & = & 885.84\cdot p_9
\end{array}\right. \tag{4.22}$$

where the unknowns p_i ($i = 1 \ldots 9$) are the unit production costs of each intermediate and final product that satisfies the above mentioned condition. Making reference to the matrix notation in Table 4.10, this system can be expressed in a compact matrix notation as:

$$\mathbf{p}^T \cdot \tilde{\mathbf{X}} = \omega \tag{4.23}$$

(where $\mathbf{p}^T$ means the transpose of the column vector $\mathbf{p}$ in Table 4.10) and it can be solved as

$$\mathbf{p}^T = \omega \cdot \tilde{\mathbf{X}}^{-1} = \left(81.6 \quad 94.4 \quad 102.7 \quad 145.8 \quad 137.8 \quad 168.1 \quad 208.8 \quad 6.9 \quad | \quad 35.3\right) \tag{4.24}$$

which yields the unit product cost expressed as €/unit. The latter includes for each manufacturing stage of the operation chain, also the treatment costs, which have been assigned according to the demand of waste treatment as well as the internal recycling.

The unit cost of producing 1 t of scrap (€145.8) is higher than the cost of producing 1 t of the main product, $b(1)$, it is associated with. This is due to the computational mechanism shown in Sect. 4.3.5, according to which all the treatment costs have been assigned to the fictitious process producing the scrap as its main output. Process $B(1)$ will be assigned only the value added part of the manufacturing costs, that amounts to €102.7 per unit of output. Without carrying out the allocation, it would have not been possible to make a distinction between the value added cost of producing $b(1)$ and the cost of producing the scrap. The unit cost of $b(1)$ would have been indeed €124.7 which includes the cost of treatment and the cost of the wasted resources.

Once the products unit cost vector **p** has been calculated, then the balanced physical flows that have been recorded in the upper partition of Table 4.10 can be turned into financial transactions. The corresponding matrix operation is:

$$_{p}\tilde{\mathbf{X}} = \hat{\mathbf{p}} \cdot \tilde{\mathbf{X}} \tag{4.25}$$

where $\hat{\mathbf{p}}$ is the diagonalised vector **p**. The outcome of this operation is shown in Table 4.13.

Tables 4.10 and 4.13 show two complementary aspects of the proposed model that concern: the production planning and assessment of process and product costs, respectively. Nevertheless, this reflects the specific aim of IOA to provide a price model which is the monetary counterpart of an underlying commodity-flow-based model (Weisz and Duchin 2006). Finally, the information shown in Table 4.13 can be turned into the equivalent T-accounts entries. Following Staubus (1971) the corresponding account flow-chart can be drawn as in Fig. 4.2.

5 Further Issues Regarding Environmental Aspects

Before closing the chapter, it is necessary to further discuss how the proposed computational structure deals with the environmental aspects. What emerged clearly throughout the chapter is that the assessment of the environmental impacts is not a direct outcome of the proposed concept of LCC. Moreover, the environmental aspects are used mainly as a driver that measures the amount of end-of-pipe treatments demanded by each production process, while taking into account also closed-loop recycling. Nonetheless, from a methodological viewpoint additional computations are possible.

1. Different kinds of effluents recorded in matrix **R** can be matched with external cost coefficients that are available in literature – although this is a widely discussed topic (see for example Cook et al. 1974, Loew 2003, Mizsey et al. 2009). Assuming a willingness to do so, externalities can be included in cost accounting by following the steps described in Sect. 4.4. The model would then result in a system of transfer prices (Schaltegger and Wagner 2005) that includes the external environmental costs sometimes called environmental transfer prices'.
2. Alternatively, it is theoretically feasible to link the physical flows in **R** with the assessment of impacts by means of additional computational steps, also based on linear algebra, that have been accurately described in the field of LCA (Heijungs and Suh 2002, ch. 8).
3. Finally, it is also possible to quantify such aspects as the eco-intensity of an organisation (see for example Schmidt and Schwegler 2008) or the energy cost of an intermediate or final product. It is sufficient that a corresponding value in terms of the appropriate physical instead of monetary terms is attributed to the externally purchased inputs. Examples include the energy which is embodied in a certain commodity expressed in MJ/unit or the eco-intensities of the externally

Table 4.13 Balanced flows in monetary terms

			Processes									
			(I)								(II)	
			A		B			C		D	E	Totals/
		Units	(1)	(2)	(1)	*scrap*	(2)	(1)	(2)			Final Dem.
	Main prod. a(1)	€	77,314.63	0	−50,467.83	−8,840.72	−18,006.07	0	0	0	0	0
	Main prod. a(2)	€	0	56,962.74	0	0	−56,962.74	0	0	0	0	0
	Main prod. b(1)	€	0	0	73,822.63	0	0	−73,822.63	0	0	0	0
	Scrap	€	0	0	0	15,801.41	0	−15,801.41	0	0	0	0
$_p\tilde{\mathbf{X}}$	Main prod. b(2)	€	0	0	0	0	100,830.19	0	−100,830.19	0	0	0
	Main prod.c(1)	€	0	0	0	0	0	121,906.71	0	−121,906.71	0	0
	Main pord c(2)	€	0	0	0	0	0	0	167,044.00	0	0	167,044.00
	Main prod c(1) – used	€	0	0	0	0	0	0	0	173,014.65	0	173,014.65
	Treatment	€	−1,175.30	−745.41	0	−3,740.99	−8,517.19	−8,143.08	−8,949.31	0	31,271.28	0
ω	Direct proc. cost	€	76,139.33	56,217.34	23,354.79	3,219.69	17,344.19	24,139.6	57,264.50	51,107.94	31,271.28	340,058.65

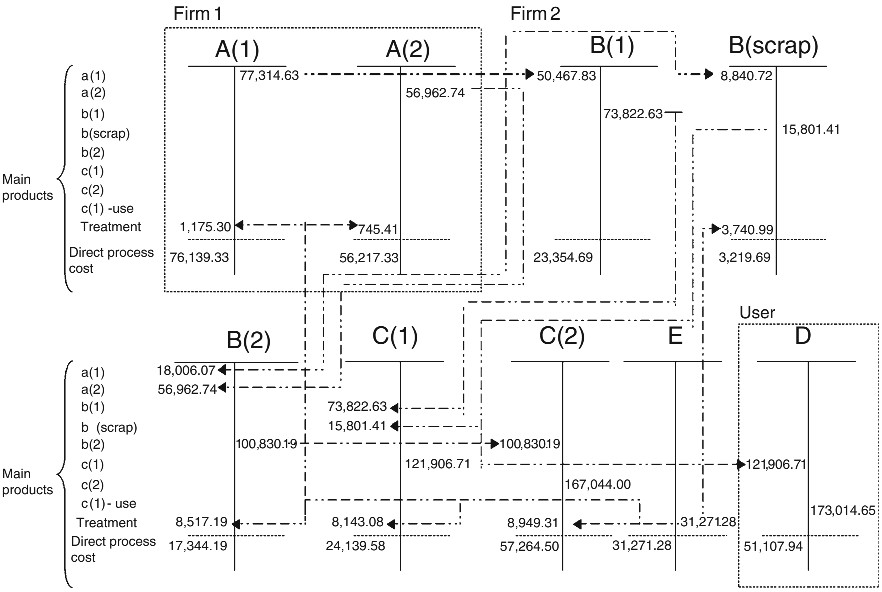

Fig. 4.2 Account flowchart

purchased inputs. For each intermediate and final product, a measure of its unit cost in physical terms, or its eco-intensity, can be then obtained by using the same computational procedure described in Sect. 4.4.

Clearly there are differences in using alternatively LCA or LCC to cover the assessment of environmental aspects and impacts. LCA is not meant for managerial planning and control, and this affects its representivity and accuracy (Schaltegger 1997). By contrast, the computational approach described above gives an accurate picture of a specific operation chain, which can be extended if necessary. However, LCC cannot attempt to adopt such a holistic approach as LCA. Rather, it should be more focussed on the actual relationships within the firm and, eventually, among SC partners. These contrasting aspects of LCC and LCA seem to be less evident within the mainstream approaches to environmental LCC, that put more emphasis on gathering cost data than on calculating them (Ciroth 2009, Hunkeler et al. 2008, Schaltegger and Burritt 2000).

6 Concluding Remarks

To achieve some degree of integration between physical and cost accounting is becoming increasingly important, since it makes it feasible to assess the repercussions of cleaner and more efficient integrated technologies on costs. Several methods already exist that pursue that aim. Yet, whatever approach is chosen, the computational aspects remain to a great extent a matter of specific computer-based applications. This raises several limitations especially if SMEs are involved. In this chapter an effort has been made to outline a generalised mathematical procedure that uses matrix algebra to model the structural elements of manufacturing processes, thus providing a basis for integrating production planning and costing methods. Life cycle costing has been chosen as a reference tool throughout the chapter. Rather than focussing on its well-established background, why it would mostly benefit from a formalised computational structure has been discussed. Current approaches to LCC, especially environmental LCC, emphasise how the computational aspects lie in some underlying cost accounting method, for example ABC. It is argued here that LCC should be self-contained and reflect the basic algebra grounded on the same applications of IOA that have been developed for LCA and SCM.

The user is expected to benefit from the outcome of the proposed approach which is to provide the manufacturing firms, especially small- and medium-sized ones, with a tool for *diagnosis*. To carry out such diagnosis may prove to be useful to a firm before committing itself to a specific information system. Software applications *per se* do not necessarily allow the practitioner to identify any rigorous analytical approach that generalises the logic and hypothesis underlying the methods for carrying out the necessary calculations, through formal evidence and to the benefit of transparency and comprehensibility.

A concept of LCC based on an input–output technological model has been presented which is consistent with some computational structures adopted in LCA and SC analysis. Using a numerical example for illustrative purposes, a formalised computational procedure has been described in detail, so that it can be implemented by means of an electronic spreadsheet. Although the proposed model of LCC is consistent with LCA and SCM, some computational differences emerged that were necessary for the accuracy of cost assignment.

Making reference to the multi-dimensional classification of EMA tools proposed by Burritt et al. (2002), the concept of LCC proposed here, defined in Sect. 4.2, can be ultimately seen as quite different from mainstream LCC, especially within EMA, since it is:

- Both hind- and fore-sight-orientated, depending on the use made of it
- Short-term focussed like environmental cost accounting up to the final production stage; if the use stage and the final disposal scenarios are considered it is long-term focussed depending on the product being durable or non-durable
- Based on continuous accounting, rather than on ad-hoc information

Given the above, its consistency with LCA which has been classified as past-orientated, long-term focussed and based on ad-hoc information is to a greater extent a matter of computational structure. LCA's concern of reducing the number of flows that are left outside the system boundaries would not necessarily improve the analysis from a cost accounting perspective. A similar concern exists in gathering cost information from different entities to implement LCC. It should be constrained by the actual SC relationships. It may prove to be neither possible nor useful, indeed, to gain insight into the cost structure of other supply chain actors. Unless a joint effort to achieve cost savings beyond the influence of a single organisation is feasible and is it the management of drivers to control cost propagation through the supply chain.

The main result that can be achieved implementing LCC, as understood here, is to make a firm aware of both the physical flows which characterise its manufacturing processes and the way they drive its production costs as well as the cost of process inefficiencies such as wastes and user's post-purchase costs. Furthermore, the concept of LCC adopted is oriented towards the supply chain, and it is intended to combine the perspectives of those SC partners which are actually concerned with jointly reducing, where possible, costs and impacts at the same time, even in the use and disposal phases of their products.

The model outlined can be *gradually* extended, following the same computational principles described to link suppliers to customers. If they both work more closely it will become a more common practice to obtain information on the cost structure of supply chain members in order to understand the cost and revenue implications of various decisions and will reduce relying solely on prices as a surrogate for cost (Ellram and Fetzinger 1997).

Two important aspects have not been dealt with in this chapter: uncertainty and dynamics. Since chasing accuracy of past figures as an apparent reduction of uncertainty can increase risk, the model should not be a deterministic one (Emblemsvåg 2003). Further research should address uncertainty issues within the model's parameters, so that the proposed method can serve as both a back-casting and a forecasting tool in order to let the analysis lead to some action. In addition, the timing aspects must be introduced, setting up a comprehensive production-inventory system which is useful to face problems related with the effects that feedbacks and recycling loops may have on production scheduling.

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References

Albino V and Kühtz S (2004) Enterprise input–output model for local sustainable development – the case of a tiles manufacturer in Italy *Resources Conservation Recycling* 41.3 165–176

Albino V, Izzo C and Kühtz S (2002) Input–output models for the analysis of a local/global supply chain *International Journal of Production Economics* 78.2 119–131

Albino V, Messeni Petruzzelli A and Yazan DM (2008) The environmental sustainability of production chains in concrete industry. An enterprise input–output approach *Proceedings of the International Input Output Meeting on Managing the Environment* (July 9–11, 2008) Seville, Spain

Artto KA (1994) Life cycle cost concept and methodologies *Journal of Cost Management* 8.3 28–32

Asiedu Y and Gu P (1998) Product life cycle cost analysis: state of the art review *International Journal of Production Research* 36.4 836–908

Bartolomeo M, Bennett M, Bouma JJ, Heydkamp P, James P and Wolters T (2000) Environmental management accounting in Europe: current trend and future potential *The European Accounting Review* 9.1 31–52

Beamon BM (1999) Designing the green supply chain *Logistic Information Management* 12.4 332–342

Bennett M and James P (2000a) The green bottom line *in* Bennett M and James P *The Green Bottom Line* Sheffield, Greenleaf

Bennett M and James P (2000b) Life-cycle costing and packaging at Xerox *in* Bennett M and James P *The Green Bottom Line* Sheffield, Greenleaf 347–361

Bennett M, Hughes A and James P (1998) Evaluating the whole-life environmental performance of products *in* Bennett M and James P *Sustainable Measures* Sheffield, Greenleaf 283–311

Bhimani A, Gosselin M, Ncube M and Okano H (2007) Activity based costing: how far have we come internationally? *Cost Management* 21.3 12–17

BMU and UBA (German Environmental Ministry, German Environmental Agency) (2003) *Guide to Corporate Environmental Cost Management* Berlin, Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU) – Federal Environmental Agency (UBA)

Boons ANAM (1998) Product costing for complex manufacturing systems *International Journal of Production Economics* 55.3 241–255

Bouman M, Heijungs R, van der Voet E, van den Bergh JCJM and Huppes G (2000) Material flows and economic models: an analytical comparison of SFA, LCA and partial equilibrium models *Ecological Economics* 32.2 195–216

Bovea MD and Vidal R (2004) Increasing product value by integrating environmental impact, costs and customer valuation *Resources Conservation and Recycling* 41.2 133–145

Bras B and Emblemsvåg J (1995) Activity-based costing and uncertainty in designing for the life-cycle *in* Huang Q *Design for X: Concurrent Engineering Imperatives* London, Chapman & Hall

Burritt R, Hahn T and Schaltegger S (2002) An integrative framework of environmental management accounting *in* Bennett M, Bouma JJ, and Wolters T *Environmental Management Accounting: Informational and Institutional Developments* Dordrecht, Kluwer 21–35

Busch T, Beucker S and Müller A (2006) Computer aided resource efficiency accounting *in* Wagner B and Enzler S *Material Flow Management. Improving Cost Efficiency and Environmental Performance* Heidelberg, Physica-Verlag 21–55

Carenzo P and Turolla A (2009) The diffusion of management accounting tools in manufacturing companies: an empirical analysis in Italian firms *Proceedings of the 9th Manufacturing Accounting Research Conference* (June 21–24, 2009) Münster, Germany

Cinqini L, Giannetti R and Tenucci A (2008) L'adozione e la "percezione di utilità" delle tecniche di Advanced Management Accounting: risultati di uno studio su un campione di aziende italiane *Finanza, Marketing, Produzione* 26.1 42–71 (Available only in Italian)

Ciroth A (2009) Cost data quality considerations for eco-efficiency measures *Ecological Economics* 68.6 1583–1590

Clark JP (1997) Cost and profitability estimation *in* Valentas KJ, Rotstein E and Singh RP *Food Engineering Practice* Boca Raton, CRC 537–557

Cook JS, Davidson LF and Smith CH (1974) Social costs and private accounting *Abacus* 10.4 87–99

Cooper R and Slagmulder R (2004) Interorganizational cost management and relational context *Accounting Organization and Society* 29.1 1–26

De Paoli L and Lorenzoni A (1999) *Economia e politica delle fonti rinnovabili e della cogenerazione* Milano, Franco Angeli (Available only in Italian)

Dhillon BS (1989) *Life Cycle Costing. Techniques, Models and Applications* New York, Gordon and Breach Science Publishers

Dimache A, Dimache L, Zoldi E and Roche T (2007) Life cycle cost estimation tool for decision-making in the early phases of the design process *in* Takata S and Umeda Y *Advances in Life Cycle Engineering for Sustainable Manufacturing Business* London, Springer 455–459

Dunk AS (2004) Product life cycle cost analysis: the impact of customer profiling, competitive advantage, and quality of IS information *Management Accounting Review* 15.4 401–414
Durairaj SK, Ong SK, Tan RBH and Nee AYC (2002) Evaluation of life cycle cost analysis methodologies *Corporate Environmental Strategy* 9.1 30–39
El-Kordy MN, Badr MA, Abed KA and Said MA Ibrahim (2002) Economical evaluation of electricity generation considering externalities *Renewable Energy* 25.2 317–328
Ellram LM (1995) Total cost of ownership. An analysis approach for purchasing *International Journal of Physical Distribution and Logistics* 25.8 4–23
Ellram LM and Fetzinger E (1997) Using total profit analysis to model supply chain decisions *Journal of Cost Management* 11.4 12–21
Emblemsvåg J (2001) Activity-based life-cycle costing *Managerial Auditing Journal* 16.1 17–27
Emblemsvåg J (2003) *Life Cycle Costing. Using Activity Based Costing and Monte Carlo Methods to Manage Future Costs and Risks* Hoboken, John Wiley and Sons
Epstein MJ (1996) Improving environmental management with full environmental cost accounting *Environmental Quality Management* 6.1 11–22
Epstein MJ (2008) *Making Sustainability Work* Sheffield, Greenleaf Publishing
Epstein MJ and Roy M-J (1997) Environmental management to improve corporate profitability *Journal of Cost Management* 11.6 26–34
Epstein MJ and Wisner PS (2002) Measuring and managing social and environmental impact *in* Shank JK *Handbook of Cost Management* New York, Warren Gorham & Lamont F9.1–F9.50
Fabrycky WJ and Blanchard BS (1991) *Life Cycle Costing and Economic Analysis* Englewood Cliffs, Prentice Hall
Fava JA and Smith JK (1998) Integrating financial and environmental information for better decision making *Journal of Industrial Ecology* 2.1 9–11
Feltham GA (1968) Some quantitative approaches to planning for multiproduct production systems *The Accounting Review* 45.1 11–26
Fixson SK (2004) Assessing product architecture costing: product life cycles, allocation rules and cost models *Proceedings of ASME 2004 Design Engineering Technical Conference* (28 September–2 October 2004) Salt Lake City, Utah
Funk B, Möller A and Niemeyer P (2009) Integration of environmental management information systems and ERP systems using integration platforms *in* Athanasiadis IN, Mitkas PA, Rizzoli AE and Gòmez JM *Information Technologies in Environmental Engineering* Berlin, Springer 53–63
Gale R (2006) Environmental costs at a Canadian paper mill: a case study of environmental management accounting (EMA) *Journal of Cleaner Production* 14.14 1237–1251
Gambling TE (1968) A technological model for use in input–output analysis and cost accounting *Management Accounting* (USA) 50.4 33–38
Gambling TE and Nour A (1970) A note on input–output analysis: its Uses in macro-economics and micro economics *The Accounting Review* 45.1 98–102
Geffen CA and Rothenberg S (2000) Suppliers and environmental innovation. The automotive paint process *International Journal of Operations and Production Management* 20.2 166–186
Gess D and Cohan D (1995) Managing life-cycle costs: applications and lessons learned at leading utilities *Total Quality Environmental Management* 4.2 43–53
Grubbström RW and Tang O (2000) An overview of input–output analysis applied to production-inventory systems *Economic Systems Research* 12.1 3–25
Gu L, Lin B, Zhu Y, Gu D, Huang M and Gai J (2008) Integrated assessment method for building life cycle environmental and economic performance. *Building Simulation: An International Journal* 1.2 169–177
Hansen DR and Mowen MM (2003) *Cost Management. Accounting and Control* (4th edition) Mason, Thomson South-Western
Heijungs R (2001) *A Theory of the Environment and Economic Systems. A Unified Framework for Ecological Economic Analysis and Decision Support* Cheltenham, Edward Elgar
Heijungs R and Suh S (2002) *The Computational Structure of LCA* Dordrecht, Kluwer

Hellgren J (2007) Life cycle cost analysis of a car, a city bus and an intercity bus powertrain for year 2005 and 2020 *Energy Policy* 35.1 39–49

Heupel T and Wendish N (2003) Green success: process-based environmental cost accounting – implementation in SME's in Germany *in* Bennett M, Rickhardsson PM and Schaltegger S *Environmental Management Accounting – Purposes and Progress* Dordrecht, Kluwer 333–363

Hochschorner E and Finnvenden G (2006) Life cycle approach in the procurement process: the case of defence material *International Journal of Life Cycle Assessment* 11.3 200–208

Hunkeler D, Lichtenvort K and Rebitzer G (2008) *Environmental Life Cycle Costing* Pensacola (FL), CRC-SETAC

Huppes G and Ishikawa M (2005) A framework for quantified eco-efficiency *Journal of Industrial Ecology* 9.4 25–41

Huppes G, van Rooijen M, Kleijn R, Heijungs R, de Koning A and van Oers L (2004) Life cycle costing and the environment *Report of a Project Commissioned by The Ministry of VROM-DGM* Leiden, CML

Hutton RB and Wilkie WL (1980) Life cycle cost: a new form of consumer information *The Journal of Consumer Research* 6.4 349–360

IFAC (International Federation of Accountants) (2005) *International Guidance Document – Environmental Management Accounting* New York, IFAC

Ijiri Y (1968) Input–output analysis in cost accounting *Management Accounting* (UK) 46.9 367–377

James KL (2003) *Environmental Life Cycle Costing in the Australian Food Packaging Supply Chain* PhD thesis, School of Accounting and Finance, Victoria University, Melbourne

James KL, O'Donovan G, Kloot L and Sonneveld K (2002) Environmental issues and accounting approaches: an Australian food and packaging industry case study *Accounting Association of Australia and New Zealand National Conference* Perth, AAANZ

Janz D, Hornberger M and Westkämper E (2006) Design for environment by target life cycle costing *in* Brissaud D, Tichkiewitch S and Zwolinski P *Innovation in Life Cycle Engineering and Sustainable Development* Dordrecht, Springer 337–348

Jasch C (2003) The use of environmental management accounting (EMA) for identifying environmental costs *Journal of Cleaner Production* 11.6 667–676

Jasch C (2009) *Environmental and Material Flow Cost Accounting* Heidelberg, Springer

Junnila S (2008) Life cycle management of energy-consuming products in companies using IO-LCA *International Journal of Life Cycle Assessment* 13.5 432–439

Kajüter (2002) Proactive cost management in supply chains *in* Seuring S and Goldbach M *Cost Management in Supply Chains* Heidelberg, Physica-Verlag 31–52

Kajüter P and Kumala HI (2005) Open-book accounting in networks. Potential achievements and reasons for failures *Management Accounting Research* 16.2 179–204

Kannan R, Leong KC, Osman R and Ho HK (2007) Life cycle energy, emissions and cost inventory of power generation technologies in Singapore *Renewable and Sustainable Energy Reviews* 11.4 702–715

Kicherer A, Schaltegger S, Tschochohei H and Ferreira Pozo B (2007) Eco-efficiency. Combining life cycle assessment and life cycle costs via normalization *International Journal of Life Cycle Assessment* 12.7 537–543

Koleian GA and Kar K (2003) Elucidating complex design and management tradeoffs through life cycle design: air intake manifold demonstration project *Journal of Cleaner Production* 11.1 61–77

Kreuze JG and Newell GE (1994) ABC and life-cycle costing for environmental expenditures: the combination gives companies a more accurate snapshot *Management Accounting* 75.8 38–42

Krozer Y (2008) Life cycle costing for innovations in product chains *Journal of Cleaner Production* 16.3 310–321

Kumaran D Senthil, Ong SK, Nee AYC and Tan RBH (2003) A proposed tool to integrate environmental and economical assessments of products *Environmental Impact Assessment Review* 23.1 51–72

Kytzia S, Faist M and Baccini P (2004) Economically-extended MFA: a material flow approach for a better understanding of food production chain *Journal of Cleaner Production* 12.8–10 877–889
Laurin L, Möller A, Prox M and Schmidt M (2006) How production-theory can support the analysis of recycling systems in the electronic waste sector *Proceedings of the 2006 IEEE International Symposium on Electronics and the Environment* (May 8–11, 2006) 272–275
Leontief W (1970) Environmental repercussions and the economic structure: an input–output approach *Review of Economics and Statistics* 52.3 262–271
Lim S-R, Park D and Park JM (2008) Environmental and economic study of a total wastewater treatment network system *Journal of Environmental Management* 88.3 564–575
Lin X and Polenske KR (1998) Input–output modeling of production processes for business management *Structural Change and Economic Dynamics* 9.2 205–226
Lindholm A and Suomala P (2005) Present and future of life cycle costing: reflections from Finnish companies *The Finnish Journal of Business Administration* 2 282–292
Livingstone JL (1969) Input–output analysis for cost accounting, planning and control *The Accounting Review* 44.1 48–64
Loew T (2003) Environmental cost accounting: classifying and comparing selected approaches *in* Bennett M, Rikhardsson PM and Schaltegger S *Environmental Management Accounting – Purposes and Progress* Dordrecht, Kluwer 41–55
Mizsey P, Delgado L and Benko T (2009) Comparison of environmental impact and external cost assessment methods *International Journal of Life Cycle Assessment* 14.7 665–675
Möller A and Schaltegger S (2005) The sustainability balanced scorecard as a framework for eco-efficiency analysis *Journal of Industrial Ecology* 9.4 73–83
Möller A, Prox M and Viere T (2006) Computer support for environmental management accounting *in* Schaltegger S, Bennett M and Burritt R *Sustainability Accounting and Reporting* Dordrecht, Springer 605–624
Mueller-Wenk R (1978) *Die ökologische Buchhaltung* Frankfurt, Campus
Nakamura S and Kondo Y (2002) Input–output analysis of waste management *Journal of Industrial Ecology* 6.1 39–63
Nakamura S and Kondo Y (2006a) Hybrid LCC of appliances with different energy efficiency *International Journal of Life Cycle Assessment* 11.5 305–314
Nakamura S and Kondo Y (2006b) A waste input–output life-cycle cost analysis of the recycling of end-of-life electrical home appliances *Ecological Economics* 57.3 494–506
Nakamura S and Kondo Y (2009a) Waste input–output analysis, LCA and LCC *in* Suh S *Handbook of Input–Output Economics in Industrial Ecology* Dordrecht, Springer 561–572
Nakamura S and Kondo Y (2009b) *Waste Input–Output Analysis* Dordrecht, Springer
Nguyen TLT, Gheewala SH and Bonnet S (2008) Life cycle cost analysis of fuel ethanol produced from cassava in Thailand *International Journal of Life Cycle Assessment* 13.7 564–573
Norris GA (2001) Integrating life cycle costing analysis and life cycle assessment *International Journal of Life Cycle Assessment* 6.2 118–120
Notarnicola B, Tassielli G and Nicoletti GM (2004) Environmental and economic analysis of the organic and conventional extra-virgin olive oil *New Medit* 3.2 28–34
Orbach T and Liedtke C (2002) Resource-efficiency accounting *in* Bennett M, Bouma JJ and Wolters T *Environmental Management Accounting: Informational and Institutional Developments* Dordrecht, Kluwer 83–90
Paranko J, Laine T, Seppänen M and Suomala P (2005) Accounting for networks – the consolidated network approach *Proceedings of the 11th International Conference on Concurrent Enterprising: Integrated Engineering of Products, Services and Organisations* (June 20–22, 2005) Munich, Germany
Pilisi A and Venturelli A (2003) Introducing environmental management accounting into small and medium-sized enterprises *in* Bennett M, Rikhardsson PM and Schaltegger S *Environmental Management Accounting – Purposes and Progress* Dordrecht, Kluwer 281–307
Rebitzer G (2002) Integrating life cycle costing and life cycle assessment for managing costs and environmental impacts in supply chains *in* Seuring S and Goldbach M *Cost Management in Supply Chains* Heidelberg, Physica-Verlag 127–142

Rebitzer G and Hunkeler D (2003) Life cycle costing in LCM – ambitions, opportunities and limitations *International Journal of Life Cycle Assessment* 8.5 253–256

Rebitzer G and Nakamura S (2008) Environmental life cycle costing *in* Hunkeler D, Lichtenvort K and Rebitzer G *Environmental Life Cycle Costing* 35–57 Pensacola (FL), CRC-SETAC

Rebitzer G Rebitzer G, Hunkeler D and Jolliet O (2003) LCC as the economic pillar of sustainability *Environmental Progresses* 11.4 241–249

Reich MC (2005) Economic assessment of municipal waste management systems – case studies using a combination of life cycle assessment (LCA) and life cycle costing (LCC) *Journal of Cleaner Production* 13.3 253–263

Rodriguez REJ and Emblemsvåg J (2007) Activity-based life-cycle costing in long-range planning *Review of Accounting and Finance* 6.4 370–390

Roes AL, Marsili E, Nieuwlaar E and Patel MK (2007) Environmental and cost assessment of a polypropylene nanocomposite *Journal of Polymers and the Environment* 15.3 212–226

Roth IF and Ambs LL (2004) Incorporating externalities into a full cost approach to electric power generation life-cycle costing *Energy* 29.12/15 2125–2144

Roy P, Shimizu N, Shiina T and Kimura T (2006) Energy consumption and cost analysis of local parboiling processes *Journal of Food Engineering* 76.4 646–655

Sampattagul S, Kato S, Kiatsiriroat T and Widiyanto A (2004) Life cycle considerations of the flue gas desulphurization system at a lignite-fired power plant in Thailand *International Journal of Life Cycle Assessment* 9.6 387–393

Schaltegger S (1997) Economics of life cycle assessment: inefficiency of the present approach *Business Strategy and the Environment* 6.1 1–8

Schaltegger S and Burritt R (2000) *Contemporary Environmental Accounting. Issues and Concepts* Sheffield, Greenleaf Publishing

Schaltegger S and Burritt RL (2010) Sustainability accounting for companies: catchphrase or decision support for business leaders? *Journal of World Business* 45.4 375–384

Schaltegger S and Wagner M (2005) Current trends in environmental cost accounting – and its interaction with eco-efficiency performance measurement and indicators *in* Rickhardsson PM, Bennett M, Bouma JJ and Schaltegger S *Implementing Environmental Management Accounting: Status and Challenges* Dordrecht, Springer 45–62

Schmidt WP (2003) Life cycle costing in design for the environment *International Journal of Life Cycle Assessment* 8.3 167–174

Schmidt M (2005) A production-theory-based framework for analysing recycling systems in the e-waste sector *Environmental Impact Assessment Review* 25.5 505–524

Schmidt WP and Butt F (2006) Life cycle tool within ford of Europe's product sustainability index *International Journal of Life Cycle Assessment* 11.5 315–322

Schmidt M and Schwegler R (2008) A recursive ecological indicator system for the supply chain of a company *Journal of Cleaner Production* 16.15 1658–1664

Schwab Castella P, Blanc I, Gomez Ferrer M, Ecabert B, Wakeman M, Manson J-A, Emery D, Han S-H, Hong J and Jolliet O (2009) Integrating life cycle costs and environmental impacts of composite rail car-bodies for a Korean train *International Journal of Life Cycle Assessment* 14.5 429–442

Settanni E (2008) The need for a computational structure of LCC *International Journal of Life Cycle Assessment* 13.7 526–531

Seuring S (2001) Green supply chain costing *Greener Management International* 33 71–80

Seuring S (2002) Supply chain costing – a conceptual framework *in* Seuring S and Golbach M *Cost Management in Supply Chains* Heidelberg, Physica-Verlag 15–30

Seuring S (2003) Cost management in the textile chain: reducing environmental impacts and costs for green products *in* Bennett M, Rikhardsson PM and Schaltegger S *Environmental Management Accounting: Purposes and Progresses* Dordrecht, Kluwer 233–256

Seuring S (2004a) Industrial ecology, life cycles, supply chains: differences and interrelations *Business Strategy and the Environment* 13.4 206–319

Seuring S (2004b) Integrated chain management and supply chain management comparative analysis and illustrative cases *Journal of Cleaner Production* 12.8/10 1059–1071
Seuring S and Müller M (2008) From a literature review to a conceptual framework for sustainable supply chain management *Journal of Cleaner Production* 16.15 1699–1710
Shank JK and Govindarajan V (1996) *Strategic Cost Management* New York, The Free Press
Shapiro KG (2001) Incorporating costs in LCA *International Journal of Life Cycle Assessment* 6.2 121–123
Shield MD and Young MS (1991) Managing product life cycle costs: an organizational model *Journal of Cost Management* 5.3 39–52
Staubus GJ (1971) *Activity Costing and Input–Output Accounting* Homewood, RD Irwin Inc
Steen B (2007) Environmental costs and benefits in life cycle costing *Management of Environmental Quality: An International Journal* 16.2 107–118
Strobel M and Redman C (2002) Flow cost accounting, an accounting approach based on the actual flows of material *in* Bennett M, Bouma JJ and Wolters T *Environmental Management Accounting: Informational and Institutional Developments* Dordrecht, Kluwer 67–82
Suh S and Heijungs R (2007) Power series expansion and structural analysis for life cycle assessment *International Journal of Life Cycle Assessment* 12.6 381–390
Suh S and Huppes G (2005) Methods for life cycle inventory of a product *Journal of Cleaner Production* 13.7 687–697
Sushil (1992) Costing and production planning using physical system theory – a case study of manufacturing of compression springs *Production Planning & Control* 3.2 141–150
Swift-Hook DT (1997) The whole life costing of wind energy *Renewable Energy* 10.2/3 247–251
Tapia M, Siebel MA, van der Helm AWC, Baars ET and Gijzen HJ (2008) Environmental, financial and quality assessment of drinking water processes at Waternet *Journal of Cleaner Production* 16.4 401–409
ten Raa T (2005) *The Economics of Input–Output Analysis* Cambridge, Cambridge University Press
Tsagarakis KP, Mara DD and Angelakis AN (2003) Application of cost criteria for selection of municipal wastewater treatment systems *Water, Air, and Soil Pollution* 142.1/4 187–210
Tuckett RF (1969) Combined cost and linear programming models of industrial complexes *Operational Research Quarterly* 20.2 223–236
Udo de Haes HA, Heijungs R, Suh S and Huppes G (2004) Three strategies to overcome the limitations of life cycle assessment *Journal of Industrial Ecology* 8.3 19–32
Ullmann AA (1976) The corporate environmental accounting system: a management tool for fighting environmental degradation *Accounting, Organizations and Society* 1.1 71–79
Utne IB (2009) Life cycle cost (LCC) as a tool for improving sustainability in the Norwegian fishing fleet *Journal of Cleaner Production* 17.3 335–344
Venturelli A and Pilisi A (2003) EMA in SMEs: ten Italian case studies *in* Bennett M, Rikhardsson PM and Schaltegger S *Environmental Management Accounting – Purposes and Progress* Dordrecht, Kluwer 309–332
Vizayakumar K, Mohapatra PKJ, Adhikari B, Srinivasan S, Sahu S and Das H (2002) Life cycle costing of woven poly sacks *Proceedings of the International Conference on Ecobalance and Life Cycle Assessment in India* (Feb 13–15, 2002) Mumbai, India
Vögtlander JG, Bijma A and Brezet HC (2002) Communicating the eco-efficiency of products and services by means of the eco-costs/value model *Journal of Cleaner Production* 10.1 57–67
Wagner B and Enzler S (2006) *Material Flow Management* Heidelberg, Physica-Verlag
Weisz H and Duchin F (2006) Physical and monetary input–output analysis: what makes the difference? *Ecological Economics* 57.3 534–541
Weitz KA, Smith JK, and Warren JL (1994) Developing a decision support tool for Life-Cycle Cost Assessment *Total Quality Environmental Management* 4.1 23–36
Wendish N and Heupel T (2005) Implementing environmental cost accounting in small and medium-sized companies *in* Rikhardsson PM, Bennett M and Bouma JJ *Implementing Environmental Management Accounting* Dordrecht, Springer 193–205
Westkämper E and Osten-Sacken v.d. D (1998) Product life cycle costing applied to manufacturing systems *CIRP Annals – Manufacturing Technology* 47.1 353–356

White AL, Savage D and Shapiro K (1996) Life-cycle costing: concepts and applications *in* Curran MA *Environmental Life-Cycle Assessment* New York, McGraw-Hill, ch. 7 1–17

Woodward DG (1997) Life cycle costing – theory, information acquisition and application *International Journal of Project Management* 15.6 335–344

Xue H, Kumar V and Sutherland JW (2007) Material flows and environmental impacts of manufacturing systems via aggregated input–output models J*Journal of Cleaner Production* 15.13/14 1349–1358

Zhang C, Han W, Jing X, Pu G and Wang C (2003) Life cycle economic analysis of fuel ethanol derived from cassava in southwest China *Renewable and Sustainable Energy Reviews* 7.4 353–366

Chapter 5
Farm Risk Management Applied to Sustainability of the Food Supply Chain: A Case Study of Sustainability Risks in Dairy Farming

Jarkko Leppälä, Esa Manninen, and Tuula Pohjola

Abstract This chapter applies corporate process and risk analysis to maintaining the sustainability of the food supply chain. Primary food producers are facing increasing demands and risks. Simple tools for managing the food supply chain and self-assessment techniques are needed to follow the requirements of the new *Food Act* in Finland and the European Union. The identification and evaluation of different types of risks on farms, such as financial, environmental or social risks, can give useful information for the management of the dairy and other food supply chains. Risk analysis is used to evaluate sustainability issues in the dairy farm milking process. The views of farm managers on sustainability risks in the milking process are compared against the demands of the dairy supply chain using force field analysis. This analysis highlights those factors and tasks that are critical to the economic, environmental and social sustainability of the dairy supply process. Process risk analysis tools can be seen as an example of a sustainability risk accounting system applied in small firm management.

Keywords Risk management • Food supply chain • Sustainable management tools • Dairy farm process analysis • Risk analysis

1 Introduction

The purpose of this chapter is to analyse the use of risk management tools in dairy supply. New solutions for sustainable management accounting and food supply chain management are also presented for use in small enterprises. The specific aim

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is to identify and analyse sustainability risks in the dairy farm case and its production processes in developing new small firm management tools using risk assessment information.

Sustainable food production must fulfil ecological, economic and social preconditions in order to produce safe and healthy products. A future concern for every food supplier will be to provide a sustainable food supply in a responsible manner (Lowe et al. 2008). The *Food Act 23/2006* of the Finnish Ministry of Agriculture and Forestry also includes new requirements and responsibilities concerning food safety, quality, information, traceability and control for food chain business operators (*Food Act 23/2006*). The Finnish *Food Act* also applies to the implementation of the European Community food law concerning food control. However, while demands have increased, there is a lack of simple sustainable development management tools to provide better information on sustainability for farm producers and the whole food supply chain. Furthermore, the measurement of production quality or sustainability systems in small- and micro-farm enterprises has been difficult (Ikerd 1993, Lowe et al. 2008, van Calker et al. 2007). In general, new management ideas using simple risk management, process analysis and information tools are required to handle small enterprise management systems.

It is said that a supply chain is as good as its weakest part, and this argument applies to the whole food system (Lowe et al. 2008, Spekman et al. 1998). For instance, one problem concerns information gaps between actors in the food supply chain. Problems with corporate information management at one point in the supply chain can also be reflected throughout the management of the whole supply chain (Ilbery and Maye 2005, Schaltegger and Burritt 2005, Spekman et al. 1998, Sundkvist et al. 2005). Actors in the product supply chain should aim towards the same goals and direction. If there are many different and opposing goals among supply chain members the supply chain will be weakened (Lee and Billington 1992, Spekman et al. 1998). If this were to happen in the food supply chain it might increase food system vulnerability.

The problem of complexity is seen in those food production supplier units where a few people operate complex farm units (as illustrated in Fig. 5.1). The main problem in the sustainable management of a farm unit is taking the farm successfully through all the demands resulting from uncertainties such as the weather, changing markets, prices, laws, politics, safety risks, diseases and environmental effects, and finally taking care of the farmer's family (Mattila et al. 2007). At the corporate level, Pohjola (1999:37–47) suggests that corporate business process analysis can be used to develop environmental and sustainability models. Because of the complex interrelations between production processes, and environmental, social and financial factors, the classification of process tasks and a case study approach can help in the analysis (Pohjola 1999, Schaltegger and Burritt 2005).

Fleisher (1990:55–58) has also argued that risk management is a fixed part of farm management, because farming is such a risky business. Without risks, however, a business could also decline to too low a level of profitability, so some risk-taking is needed. Nevertheless, one problem for sustainability can be that farm production, in particular risks, overly constraining the adoption of sustainable farming practices (de Buck et al. 2001).

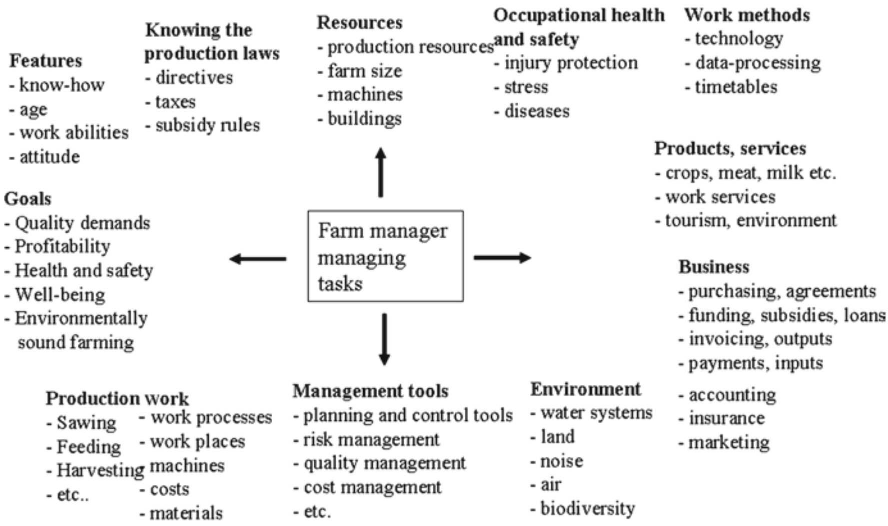

Fig. 5.1 The farm management system, illustrating the various tasks of farmers (Leppälä et al. 2008)

In general, risks are specific hazardous events and consequences that have a particular probability of occurrence. For a risk management process, there are close connections with quality management. They typically need to consider the separate phases of preparation, problem identification, assessment, control activities and documentation (COSO 2004, Juran and Godfrey 1998, SFS-IEC 60300 2000). For a farm manager, these risks are usually seen from the perspective of the whole farm or production process (Huirne et al. 2007, Leppälä et al. 2008, Suutarinen 2003). One process task may include many types of risks to the process objectives or demands (Carnaghan 2006). For example, a good preventive practice in changing situations or where there are significant operational risks is to identify and take note of the risks when planning, making decisions and carrying out work. In this study, dairy farm and milking process risks are analysed and classified as an example of the integration of sustainable management accounting and risk management methods.

2 Establishing a Sustainable Food Supply Chain

Food supply chains include the networking of actors involved in manufacturing and distributing food products from farm to fork (Lowe et al. 2008). Primary food producers or agricultural suppliers can be seen as an important phase in the food supply chain or food production. A sustainable food supply chain must be based on controlled sustainable farm management. Good farm control is essential because of the uncertain and risky character of farming and the considerable responsibilities concerning food products.

2.1 Sustainable Food Suppliers

Sustainable management of the food supply chain should start at the farm management level, integrating environmental health, social equity and economic profitability issues in production. From a systems perspective, it is important to understand the broader issues and how to use tools for practical management planning, decision making, operations, controls and farm development. Sustainable development requires understanding of responsibility for future generations and their long-term needs. There is also a need to take a broader view than simply a local one and to consider all stakeholders in the food supply chain (Lowe et al. 2008, Malkina-Pykh and Pykh 2003). Sustainable agro-ecosystems should consider at least the following common criteria (Malkina-Pykh and Pykh 2003):

- Maintenance of farm productivity and employment;
- Preservation and protection of natural resources; and
- Maintenance of a good quality of life.

Market factors are also important in the food supply chain. One of the main issues for modern enterprises is the value drivers in corporate social responsibility. These value drivers include a good corporate ethical image on the market, organisational learning and motivated employees (successful recruiting), direct financial effects (cost-saving operations), market effects (increasing sales) and risk management related to corporate social responsibility (Schaltegger and Wagner 2006, Weber 2008). Furthermore, environmental support provided to agriculture can be seen as a direct financial means to compensate for those environmentally friendly farm activities that are less profitable than, for example, intensive farm production activities. The price level of food is often associated with social and ethical issues.

2.2 Demands on the Dairy Supply Chain in Finland

In the case of dairy production in Finland, quality of milk is the most important competitive factor for Valio, the biggest dairy company in Finland (Valio 2007a). Milk as a food product is highly vulnerable to contamination which must be prevented. Milk has five important production quality dimensions which the majority (at least 86%) of Finnish dairy farms monitor through quality contracts (Valio 2007a). According to the milk quality handbook, producers must ensure milk quality and hygiene, the quality of animal fodder and drinking water, animal health and welfare, instructions for dairy processes and milk cooling and instructions for a good dairy farm environment (Valio 2007b). Many of these dairy regulations are derived from European Union's food regulations and quality criteria (*Regulation (EC) No 853/2004* of the European Parliament and the Council 2004). E-class milk, as defined by the dairy companies, is the best quality class of milk in Finland, having a bulk milk cell count of less than 250,000 cells/ml and a bacterial count of less than 50,000 colony forming units (cfu)/ml. The dairy industry takes in only E-class and first-class (cell count less than 400,000 cells/ml and bacterial count less than 100,000 cfu/ml) milk. In Finland, 92.5% of the milk produced is E-class (FAM 2009, Valio 2009). The dairy farmers' milk quality handbook includes the instructions for good milk production practices (Valio 2007b).

The dairy production process includes complex emission problems and requires many skills of the farmer. The main environmental effects on dairy farms result from animal shelters, transportation of animals, dairy cows themselves and their manure, cultivation and the use of fertilisers and pesticides. Risks include the run-off of nitrogen and phosphorus to water systems, ammonium emissions to the atmosphere, the use of non-renewable fuels and materials, the intensive use of renewable land resources and a decline in biodiversity, because of the use of chemicals and monoculture in farming (Grönroos and Seppälä 2000, Uusi-Kämppä et al. 2003). In addition, farm statistics and research indicate that there are many occupational safety risks on dairy farms, as well as the risk of work strain (Leskinen 2004, Rautiainen et al. 2009). Before joining the European Union, farms have been rather small in Finland and their growth has led to economic and social challenges (Sonkkila 2002). Dairy farmers have also had to increase farm size, take new loans, increase productivity, add farmer networks, bear greater stress and use more time for working to maintain their income levels (Leskinen 2004).

Further along the milk supply chain, dairy cooperatives collect the milk from farms and transport it to dairy production units. Milk is cooled to 4°C after milking. The truck driver checks the milk prior to pumping and takes necessary milk samples. The milk temperature must not exceed 10°C (Valio 2007a,b). A second sample is taken before the milk is pumped to the production plant. Tests are carried out in every phase during the transfer of milk from the farm to the table. Hazard analysis and critical control points (HACCP) planning is also applied in the dairy process. Milk testing is the key method of control. Most of the milk consumer packaging is recycled to take account of the whole dairy product life cycle. Risk management objectives are usually focused on dairy industry strategic and operational risks. Strategic risks are linked to the marketing strategy, the challenges of meeting consumer demands, product safety and image of the dairy products. Operational risks are linked to animal diseases, information systems, milk logistics and regional production vulnerability (Valio 2007a).

Under the new *Food Act*, food product retailers have a responsibility to monitor or ensure that food products cause no harm to consumers. The new *Food Act* in Finland and the European Union includes requirements for food supply chain information concerning traceability and business operators and self-checking plans for food producers (*Food Act 23/2006*). Sustainability accounting and reporting systems should consequently also be developed for small farm enterprises.

3 Research Methods

The case study data focuses on small farm enterprises and the dairy farm process. The selected case was a dairy farm in the south-western part of Finland. Data were collected in a series of three semi-structured interviews with diary farmers and through questionnaires concerning risk sources relating to aspects of the farm environment, safety, production, economics and assets. This study is part of larger farm management project to design easy-to-use management tools for farmers.

The interviews were recorded and transcribed. In the first interview, the farmer describes the farm's actual milking process task by task. One researcher assisted in the process description and a second evaluated the process and asked about the risks in current tasks. In the second interview the data from the process analysis was used to identify critical sustainability check points and risks in the milking process. The farmer also described risks in the milking process and issues managed on the farm. Before the risk analysis was undertaken, the farmer's background, objectives and farm resources were clarified. In the third telephone interview, the farmer evaluated various risks and issues on the farm according to sustainability objectives.

The results from the milking process are classified into three sustainability dimensions: economic, environmental and social. Perceptions of the dairy farmer are used as a baseline against which to compare general sustainable production demands and objectives through force field analysis. Force field analysis is a management tool that has also been applied in prior corporate responsibility studies (Harwood and Humby 2008). The objective is to enable the farm manager to control the environmental, social and economic risks that might have adverse effects on the food supply chain and food marketing. Evaluation points are also assigned to the farm's restraining and contributing drivers. The farmer checked and verified the results relating to her farm.

4 Results

4.1 The Dairy Farm Case

Background information was collected on the farm selected in order to establish the farm context and its resources prior to the risk analysis. The farm was a medium-sized dairy farm located in Pirkanmaa in the south-western part of Finland (Fig. 5.2) and having 40 ha of fields and 70 ha of forest. As the location is in Northern Europe it is typical to have rather cold winters with snow on the ground. Pirkanmaa has many lakes and water systems. The livestock comprise 20 cows and 8 calves. The farmer was a 44-year-old female who owned the farm and usually carried out the milking and some of the field work. The cows were milked in a tie stall with the help of a pipeline milking machine. The cattle shed is rather old and some of the equipment and methods date back to the 1970s or 1980s. The farmer's

Fig. 5.2 Location of the case study farm in Finland, Europe (S. Thessler, MTT)

family included a husband and teenage children. The husband, who carried out field work and repaired machinery, also had a part-time job outside the farm. The children did not help with the farm work very much. Other assistance with farm labour was provided by the communal farm replacement worker services and the farmer's elderly father and mother, who lived next to the farm and were the former owners.

The number of dairy farms has decreased in recent years in Finland. In 2000 there were a total of 22,913 dairy farms but only 15,714 farms in 2006 (TIKE 2001, 2008). The dairy farm studied utilised typical dairy processes and working methods in a tie stall, where cows are tied up to a stall in which they lie down, eat and are milked. Additional products or services and work processes included forest work and subcontracting with other farmers. The average dairy herd size in Finland in 2006 was 19.7 cows (TIKE 2008). The case farm was about an average size.

4.2 Risks in the Milking Process

The risk analysis was based on a description of the production process. Those issues that are important for the sustainability of the milking process also need to be protected from hazards and risks. The whole milking process had to be carefully planned and organised. Food quality demands and milk production regulations were considered in this planning. The farmer had a breeding plan for the cows, a feeding plan, an animal treatment and health plan, and a fodder production and purchasing plan, while the quality of the cattle shelter and all the necessary equipment was checked. These plans and checks were essential to maintain the milking process and had to be followed each day when the farmer entered the cow shelter at 5.30 am.

Tasks in the actual milking process include feeding and milking the cows, washing the equipment, cleaning the shelter and concluding the milking session. The milking process and associated tasks are summarised in Table 5.1. The most intensive part of the process is milking during which many tasks are carried out in a short time and many instructions about quality have to be remembered. The milk is transported through a pipeline to a milk tank which has to be hygienic and maintained at an optimal temperature. Other critical issues relate to the volumes, material and production methods, which are planned and chosen by the farmer. These tasks also have considerable safety and environmental considerations. Equipment washing is also critical because the value of the milk decreases if it contains impurities. Milk producers have a quality payment system which has an effect on the income of farmers. The quantity and quality of the tasks directly affects the quality and profitability of milk production. After checking the process, the potentially important risks were identified. These are listed chronologically in Table 5.1. This quality evaluation is carried out routinely and rapidly.

An important and helpful quality indicator for the milking process, which is highly dynamic, is to be aware of deviations from the normal situation and how significant or harmful the source of any deviation is. When such deviation is noted to be risky it should be prevented, rectified or the damage should be minimised before a risk occurs. If the deviation is harmful and a signal is observed before the risk occurs it may stop the process for a while but the risk of causing more problems is prevented.

Sometimes the prevention of a risk or catastrophe can depend on actions being taken within a few seconds. The farmer in this case study also considered that knowledge of potential risky situations or points in the process can be a catalyst for, and speed up of, rescue or preventive actions. This result has also been recorded in other safety studies (Kuusisto 2000, Reason 1995, Salminen 1997). However, information and education about risks is inadequate. According to the case farmers, it often takes time to transfer learned skills into practice, because of a lack of time and because farmers are so used to following routine working habits (Leppälä et al. 2008). However, promotion of good and safe work practices and engineering control for risk prevention are also important (Kuusisto 2000).

Table 5.1 Process tasks and possible risk issues in milking

Process phase	Priority issues in the process input	Possible risks as an output
Preparation for the milking process (process management)	• Knowledge of instructions for equipment, milk handling and animal treatment • Setting of objectives • Checking of the feeding plan • Animal breeding plan • Checking the condition of the cattle shelter • Insurance	• Instructions or objectives forgotten • Structural problems with the cattle shelter or fire risks • Mistakes or misunderstanding in instructions, plan measures, data handling • Wrong or poor objectives, poor scheduling • Misunderstanding of demands or instructions • Poor preparation causing stress and consuming time • If the production plan fails, no profit is gained
Feeding	• Good quality and sufficient volume of silage, grain and hay • Tractor in a good state • Feeding aisles are clean • No manure in stalls • Water for cows	• Fodder runs out • Fodder is spoilt, which can reduce milk quality • Tractor does not work • Tractor accident • Animal health risk • Safety risk for the farmer (pushing by cows, dust from animals) • Slipping or falling of worker or animal • Production stops or decreases
Milking	• Temperature of the milk tank • Order of milking cows (sick ones last) • Milk transport line to the milk tank • Cleaning of udders and checking of the milk • Observation of milk flow and quality • Post-treatment of the teats • Checking of the condition of the milking machine	• Milk tank disorders result in spoiled milk • Spoiled milk or dirt gets into the milk tank • Milk losses and profit losses • Animal health risk • Dumping of milk in the wrong way is an environmental risk • Kicking and pushing by cows are safety risks for the worker • Bad ergonomics cause muscular diseases in the worker

(continued)

Table 5.1 (continued)

Process phase	Priority issues in the process input	Possible risks as an output
Washing the equipment	• Washing of the milking units and all milking equipment • Switching on the automatic wash for the milking machine • Cleaning of milk from the floor	• Dirty pipes cause impurities in the milk and a loss of profit • Some equipment may remain dirty and spoil the milk • There is a possible risk that wash waters get into the milk tank • A slippery floor is a safety risk for workers • Washing detergents can cause allergic reactions in workers • An unclean floor smells bad and is unhygienic and slippery
Cleaning the stall	• Cleaning of the stall • Switching on of the manure machine • Checking of manure storage	• It is an animal health and milk quality risk if the parlour remains dirty • Slippery manure can cause slipping and falling and is a safety risk • Faults and repair of the manure machine take time, stop other work and can cause a safety risk • Bad manure storage is an environmental risk for water, air and the ground; manure spreads disease and smells
Concluding the milking process	• Feeding • Bedding • Final condition check on and observation of heat signals in the cows	• It is an animal welfare and production risk if cows are not observed regularly and treated well • Cow digestion slows down • Animal breeding fails • Fire risks

4.3 Categorizing Sustainability Risks in the Milking Process

The classification of risk issues helps in making evaluations and decisions (Table 5.2). To analyse sustainability, risks in environmental, social and ethical, and economic issues identified from the milking process were compared against the

Table 5.2 Summary of sustainability related factors in the milking process

Process phase	Environmental issues	Social and ethical issues	Economic issues
Preparations for milking	Environmental demands and plans (biodiversity, genotypes, waste program, less or integrated chemical use, saving energy, material consumption and choices, etc.)	Consumer demands, animal health, worker safety demands, order in cattle shelter, instructions for replacement worker, cultural image and animal genotypes	Income objectives, realistic schedule plan, production quality demands, efficiency demands, property protection, insurances paid
Feeding	Water quality, fodder production and consumption, fuel use, tractor exhaust, energy use, fodder waste	Worker safety, (dust, ergonomics, cow behaviour), cow welfare, cattle shelter quality, fodder storage quality, fodder transportation	Fodder costs, fodder quality, working costs, critical point for profit
Milking	Water use, energy use, milk waste, material choices, noise	Milk quality, milk product safety, worker safety (pathway slipping, ergonomics, cow behaviour, stress), cow health, safety and treatment	Milk yield, milk quality, material costs, working costs, critical point for profit
Washing and cleaning	Water use, waste waters, manure handling, chemical use, energy use, material choices, smell	Milk product safety, worker safety (slipping, falling, skin allergy, ergonomics), cow welfare and safety, manure storage and transportation, smell and safety on the area, production image	Material costs, working costs, production quality and profit
Closing the milking procedure	Fodder use, durf use, cows' natural behaviour	Cow welfare, health and treatment, worker safety, fire risk prevented	Production quality and profit, fodder costs, durf costs, breeding costs

dairy production demands listed in section three. The risk issues listed were classified by their main output effects and placed under the sustainability categories in Table 5.2. This made it easier to identify possible sustainability connections within the milking process and between the tasks. These are the sources of process output, which can be used for measuring risk. For example, in the milking process the connections for environmental outputs were the use of water and energy, the leakage of milk as waste, material choices and the noise of milking machines.

In the same milking phase there were also social and ethical indicators such as milk product quality and safety for consumers, worker safety issues and the health and treatment of the cows. Likewise, economic outputs included the milk yield and milk quality to gain profit linked to material costs and working costs.

5 Force Field Analysis

Force field analysis was used to evaluate those factors that drive movement towards sustainability goals and those restraining such movement in the dairy process. The goal was to control the risks at the dairy supplier level (see Sect. 3). The left side of a force field diagram presents the driving forces promoting change, which in this analysis are things to be kept in order on the farm. On the right side are the restraining forces against reaching the goal, and which are analysed as threats or risks. Force field analysis can also be used in assessing issues, prioritising and monitoring risks in accounting by allocating points according to how significant the issues are (Harwood and Humpy 2008). Points are allocated for every issue to indicate how significant the issue is to the milk production process from the farmer's perspective. A Likert-type scale is used with a score of one indicating not a significant issue and five a very significant issue on the dairy farm. Subsequently the number of positive and negative points can be compared. Criteria for allocating points were developed to monitor issues in the production process. In this case, the criteria were defined in the risk analysis of the milking process.

5.1 Environmental Issues

The first force field diagram (Fig. 5.3) concerns environmental issues on the case dairy farm. The farmer did not consider her farm to have significant environmental risks. However, the most obvious risk was that from milk leakage to the environment. A five hundred litre milk leak is very difficult and expensive to clean. It also rapidly begins to smell and may cause hygiene and disease problems. The open storage of manure was not a great risk to the environment in the farmer's view. However, she was aware of studies indicating that it might have effects on the atmosphere from the release of methane gas. Manure and its bacteria can also be washed into natural water systems with rain water but in this case there were no ditches nearby. Manure is transported to the fields once a year in both solid and slurry forms.

The points in Fig. 5.3 illustrate how the farmer in this case evaluated environmental sustainability issues and their significance on the farm. There are more factors contributing towards the control of environmental issues than there are restricting factors and risks. The farmer considered the most important point to be that her farm emissions were scattered and so small that they could not impact on environmental sustainability or the farm's ability to produce food. Farming is,

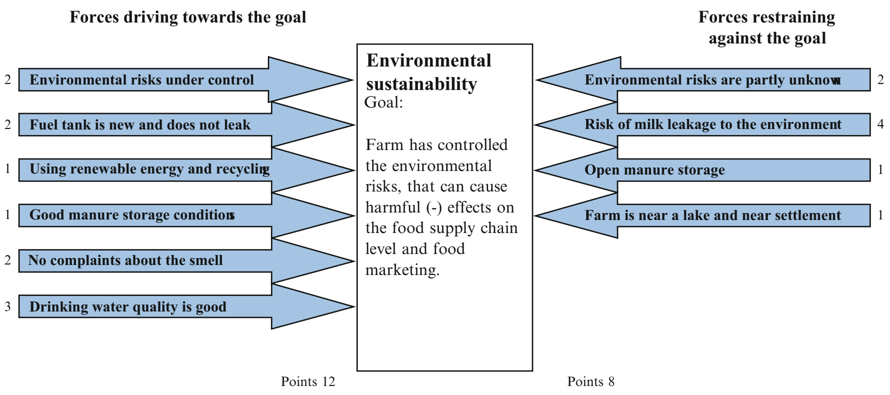

Fig. 5.3 Force field analysis for the sustainability of environmental issues

however, based on natural resources and the farmer's assumptions and perceptions need to be set against more objective measures or evaluation criteria to provide better accounting information on environmental risks. There is a risk of dairy farming having a poor environmental image which could be harmful to the sales of dairy products. There are also demands set in connection with environmental supports and the farmer's own interest in keeping the farm environment clean and comfortable to live in.

5.2 *Social and Ethical Issues*

According to the farmer, there were more significant risks to social and ethical than to environmental sustainability (Fig. 5.4). This view was based on consideration of the farmer's own welfare, consumer welfare and animal welfare as social sustainability issues. For example, milk quality and safety to the consumer is also important to the profitability of production. However, the farmer viewed the milk quality safety risk as being rather low because the farm had produced E-class milk for 15 years without problems. Nevertheless, some incidents could occur that might spoil the daily milk produced. Costs for such incidents would amount to about € 200 for the farm. However, if spoiled milk enters the upper supply chain level to the dairy co-producer process the costs will rise. This is an example of how risks to primary production become greater when moving up the food supply chain.

The farmer evaluated good personal health as a significant factor contributing to social sustainability. Working alone and occasionally under stress acts against welfare at work. It is significant that the case farm had no backup energy supply system so that a power cut might stop production for one day and cause milk quality

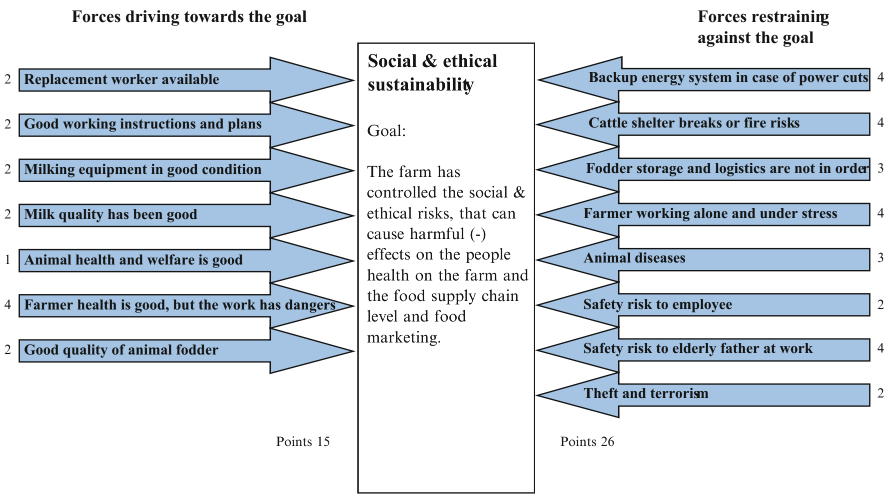

Fig. 5.4 Force field analysis for the sustainability of social and ethical issues

problems. Structural problems with the cattle shelter and fire risks were also considered as significant social risks for animal health as well as risks for society. A fire on a farm is terrible catastrophe for the whole neighbourhood if it results in large animals running wild through the area and also for those areas threatened by a large release of toxic gases. This is also an issue for which the farmer is responsible to the neighbourhood.

Animal disease epidemics were considered unlikely in the area, but still possible, and would be very significant to the farm. Employee safety was normally good but farm work sometimes carries risks. While the risks are not very significant for professional workers other workers also need to be taken into account. The farmer took care of her elderly parents who were still living nearby and carried out some work on the farm. According to statistics, the safety risk in farm work is very likely to be higher for older people (Rautiainen et al. 2009). Theft and terrorism could always be possible risks, because the cattle shelter was kept unlocked, but in the farmer's view there was nothing worth taking and they had a dog to warn of unwanted guests. However, the allocation of points by the farmer for social and ethical sustainability issues indicated that there were some important areas for improvement. The main social threats on the dairy farm were from failures in milk quality or safety, farmer health and welfare or cattle health. Risks to milk quality and milk spoilage were also considered as the biggest threats for the whole food chain, but it should be noted how other issues such as fodder quality, animal health and the organisational skills of the farmer have a possibility to affect milk quality. The causes and consequences of risks might have an integrating character. In social and ethical issues there were more negative forces than positive at the time. These issues need to be improved and carefully monitored in the future.

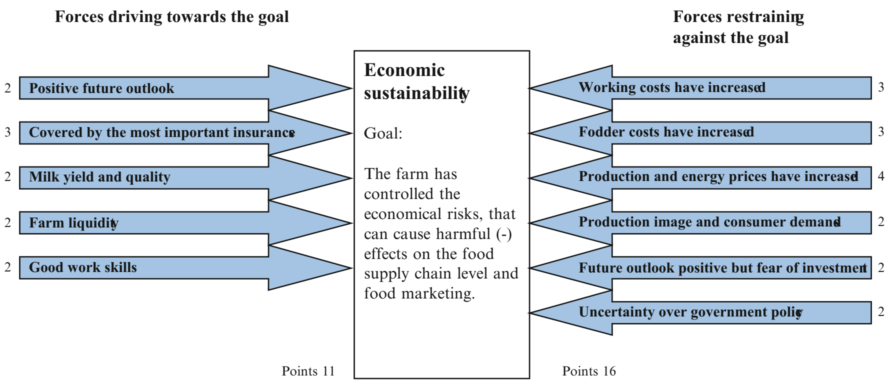

Fig. 5.5 Force field analysis for the sustainability of economic issues

5.3 *Economic Issues*

Economic issues were mainly linked to the profitability of production, such as milk yield and quality (Fig. 5.5). Production issues seemed to be well controlled but increasing production costs presented the biggest risk to the economic sustainability of the farm. In particular, the costs of energy, fodder and labour are significant. Farm insurance was in order but the farmer said that she may not be aware of the latest insurance policies. The issues of working skills and the outlook for the future were also managed in a sustainable way and presented no significant risks. Forces restraining against economically viable farming were mainly due to increasing production costs. Uncertainty over the image of dairy production, consumer demands and governmental policy were not considered as very significant issues, but might nevertheless restrain the development of the farm and investments. Thus, the allocation of points illustrates that on the case farm there were more negative forces restraining against than driving towards the economic sustainability of milk production at the time.

One threat to the milk supply chain is that the profitability of dairy farms may collapse. This could happen, for example, because of increasing costs and decreasing producer prices. A decline in the number of dairy farms would be a problem for the whole milk production chain. Milk transport times and costs would increase if dairy farms became rare in an area, but logistical costs would be compensated if farm sizes and milk production volumes increased.

6 Discussion and Conclusions

A single dairy process case was analysed in-depth to identify sustainability risks. Although the information and the data collected cannot be generalised to other cases, the aim of this article was to take a pragmatic approach in analysing risks and sustainability in a production process. The purpose was to integrate information on sustainable management and risk management from the primary supplier level to improve the management of the supply chain. These methods should be further developed to form an easy-to-use and rapid risk evaluation system.

This single dairy farm case provided a good illustration of the complexity of sustainability problems in farm production and the effects on the food supply chain. Different risks and their causes and consequences might be linked. The main risks to the sustainability of the food supply chain arising from the farm were that:

- The image of the whole food chain could suffer from farm-level environmental problems;
- Food safety could collapse if there is a collapse in food quality;
- Animal diseases could lead to a collapse in the food markets and would be a catastrophe for farmers in the affected area; and
- Problems with farmer health will affect profitability.

The analysis revealed that the case farm had sustainability risks that could have harmful effects in-farm and on the sustainability of the whole food supply chain. Risk analysis provides the farm manager and dairy supply chain managers with accounting information upon which to focus and develop evaluation measurement in farm suppliers. In this case, the main risks for the whole dairy supply chain are the environmental effects of farms and risks to the image of farming, animal health and disease risks, milk quality risks, profitability and welfare risks for suppliers and milk production interruptions in a particular area.

However, despite the problems with sustainability, many positive factors were also noted that contributed towards achieving the goals. These positive factors act as buffers against the risks. There is no sense in collecting risk management information if means for preventing risks are not developed. To use these results in formulating a farm unit development plan, the farmer needs tools for documentation and criteria to evaluate the risks. For example, risk identification checklists could be used to evaluate certain risky areas or actions on farms or in other enterprises. It was found that questions were more easily answered if the farm manager could connect them to some place or area, to working processes, production goals or some defined demands or categories. Questions could also be used to evaluate or measure a particular risk, but the formulation of the questions should be carefully considered. Risks can be categorised according to the risk focus, source or potential consequences, and can be evaluated from the perspective of a particular place, action, process phase or task.

Risk analysis included in management accounting can give useful information for managers to support their decision making. This case study can be seen as an example of a sustainability risk accounting system applied to the dairy process. Here, the food producer could obtain information for development plan or sustainability reporting using information on the production process, assessed risks from environmental effects, production costs and safety issues, consideration of the sustainable management of the enterprise and the control of supply chain management. Although there is a need for more objective information, risk analysis can be used to show which issues are the most important to address and the first to be resolved. Key concept lists or question checklists can be used, for example, as measurement or evaluation tools to assist in management.

Analysis also revealed the need for better food supply chain management. The goal of a sustainable food chain should be the responsibility of all participants in the food system, including farmers, labourers, policy makers, researchers, retailers and consumers. Each of these food system groups has its own important contribution to the whole food supply chain. Moreover, if vulnerability and uncertainty in food production and the food market increase, there will be a great need in any country to monitor and evaluate food system security in the near future.

References

Carnaghan C (2006) Business process modelling approach in the context of process level audit risk assessment: An analysis and comparison *Periodical International Journal of Accounting Information Systems* 7.2 170–204

COSO (Committee of sponsoring Organizations of the Treadway Commission) (2004) Enterprise risk management – Integrated framework Executive summary [online] [cited 28 Jan 2009] Available from Internet URL <http://www.coso.org/Publications/ERM/COSO_ERM_ExecutiveSummary.pdf>

de Buck A, van Rijn I, Röling N and Wossink G (2001) Farmer's reasons for changing or not changing to more sustainable practices: An exploratory study of arable farming in the Netherlands *Journal of agricultural education and extension* 7.3 153–166

Regulation (EC) No 853/2004 of the European Parliament and the Council (2004) Laying down specific hygiene rules for on the hygiene of foodstuffs *Official Journal of the European Union* 139/55

FAM (Finnish Association for Milk hygiene) (2009) [online] [cited 14 Oct 2009] Available from Internet URL <http://www.maitohygienialiitto.fi/index_engl.html>

Fleisher B (1990) *Agricultural Risk Management* London, Lynne Rienner Publishers

Food Act 23/2006 (2006) Ministry of Agriculture and Forestry Finland [online] [cited 28 Jan 2009] Available from Internet URL <http://www.finlex.fi/fi/laki/kaannokset/2006/en20060023.pdf>

Grönroos J and Seppälä J (2000) *SY431 Maatalouden tuotantotavat ja ympäristö (Summary: Agricultural Production Systems and the Environment)* Helsinki, Finnish Environment Institute

Harwood I and Humby S (2008) Embedding corporate responsibility into supply: A snapshot of progress *European Management Journal* 26.3 166–174

Huirne RBM, Meuwissen MPM and van Asseldonk MAPM (2007) Importance of whole-farm risk management in agriculture *in* Weintraub A, Romero C, Bjorndal T and Epstein R *Handbook of Operations Research in Natural Resources* New York, Springer

Ikerd J (1993) The need for a systems approach to sustainable agriculture *Agriculture, Ecosystems and Environment* 46.1–4 147–160

Ilbery B and Maye D (2005) Food supply chains and sustainability: Evidence from specialist food producers in the Scottish/English borders *Land Use Policy* 22.4 331–344

Juran JM and Godfrey AB (1998) *Juran's Quality Handbook* New York, McGraw-Hill

Kuusisto A (2000) *Safety Management Systems – Audit Tools and Reliability of Auditing* Espoo 2000 Technical Research Centre of Finland, VTT publications 428

Lee H and Billington C (1992) Managing supply chain inventory: Pitfalls and opportunities *Sloan Management Review* 33.3 65–73

Leppälä J, Murtonen M, Suokannas A, Lehto M, Sinisalo A and Suutarinen J (2008) *Maatilan turvallisuuden johtaminen – maatilan riskien tunnistamisen ja arviointivälineiden kehittäminen*

(Abstract: Farm Safety and Security Management – Development of Farm Risk Identification and Evaluation) MTT Research series 126 Vihti Finland, MTT Agrifood Research

Leskinen J (2004) *Saloseudulta EU-isännäksi – lypsykarjayrittäjät muutosmurroksessa (Abstract: Dairy Farmers in a Period of Transition)* Työ ja ihminen Research report 24 Ph.D. Helsinki, Finnish Institute of Occupational Health

Lowe P, Phillipson J and Lee R (2008) Socio-technical innovation for sustainable food chains: Roles for social science *Trends in Food Science & Technology* 19.5 226–233

Malkina-Pykh I and Pykh Y (2003) *Sustainable Food and Agriculture* Southampton, WIT Press

Mattila TEA, Kaustell KO, Leppälä J, Hurme T and Suutarinen J (2007) Farmers' perceptions of necessary management skills in Finland *Journal of Agricultural Education and Extension* 13.4 287–300

Pohjola T (1999) *Environmental Modelling System – A Framework for Cost-Effective Environmental Decision-Making Processes* FEMDI Research Series 12 Oitmäki, Finnish Employers Management Development Institute

Rautiainen R, Ledolter J, Ohsfeldt R, Donham K and Zwerling C (2009) Risk factors for serious injury in Finnish agriculture *American Journal of Industrial Medicine* 52.5 419–428

Reason J (1995) A systems approach to organizational error *Ergonomics* 38.8 1709–1721

Salminen S (1997) *Risk Taking, Attributions and Serious Occupational Accidents* People and work research reports 13 Helsinki, Finish Institute of Occupational Health

Schaltegger S and Burritt R (2005) Corporate sustainability *in* Folmer H and Tietenber T *The International Yearbook of Environmental and Resource Economics 2005/2006: A Survey of Current Issues* Cheltenham, Edward Elgar Publishing 185–222

Schaltegger S and Wagner M (2006) Managing and measuring the business case for sustainability: Capturing the relationship between sustainability performance, business competitiveness and economic performance *in* Schaltegger S and Wagner M *Managing the Business Case for Sustainability: The Integration of Social, Environmental and Economic Performance* Sheffield, Greenleaf 1–27

SFS-IEC 60300-39 (2000) *Dependability Management – Part 3: Application Guide Section 9: Risk Analysis of Technological Systems* Helsinki, Finnish Standards Association

Sonkkila S (2002) *Farmer's Decision Making on Adjustment into the EU* Ph.D. Publications 34 Helsinki, Helsinki University

Spekman R, Kamauff J and Myhr N (1998) An empirical investigation into supply chain management: A perspective on partnerships *International Journal of Physical Distribution & Logistics Management* 28.8 630–650

Sundkvist Å, Milestad R and Jansson A (2005) On the importance of tightening feedback loops for sustainable development of food systems *Food Policy* 30.2 224–239

Suutarinen J (2003) *Occupational Accidents in Finnish Agriculture –Causality and Managerial Aspects for Prevention* Ph.D. Agrifood Research Reports 39 Vihti, Finland, MTT Agrifood Research

TIKE (2001) *Yearbook of Farm Statistics 2007* Helsinki, Information Centre of the Ministry of Agriculture and Forestry Helsinki, Finnish Ministry of Agriculture and Forestry

TIKE (2008) *Yearbook of Farm Statistics 2007* Helsinki, Information Centre of the Ministry of Agriculture and Forestry Helsinki, Finnish Ministry of Agriculture and Forestry

Uusi-Kämppä J, Yli-Halla M and Grek K (2003) *Lypsykarjataloudesta tulevan ympäristökuormituksen vähentäminen (Abstract: Reducing Environmental Loading from Dairy Farming)* 25 Jokioinen Finland, MTT Agrifood Research Finland, MTT Publications

Valio (2007a) *Yritysvastuuraportti ja vuosikertomus 2007 (Corporate responsibility reports)* Helsinki, Valio LTD

Valio (2007b) *Maidon laatukäsikirja 2007 (Milk quality handbook 2007)* Helsinki, Valio LTD

Valio (2009) *Sustainability: Valio's Corporate Responsibility in 2008* [online] [cited 14 Oct 2009] Available from Internet URL <http://www.valio.fi/portal/page/portal/valiocom/Sustainability>

van Calker K, Berentsen P, de Boer I, Giesen G and Huirne R (2007) Modelling worker physical health and societal sustainability at farm level: An application to conventional and organic dairy farming *Agricultural Systems* 94.2 205–219

Weber M (2008) The business case for corporate social responsibility: A company-level measurement approach for CSR *European Management Journal* 26.4 247–261

Part III
Social Issues

Chapter 6
Companies, Stakeholders and Corporate Sustainability – Empirical Insights from Hungary

György Málovics, Izabella Szakálné Kanó, and Szabolcs Imreh

Abstract Corporate sustainability is an increasingly popular concept in management research. Many projects aim to lead the business sector to see beyond its standard goals and voluntarily contribute to social and environmental goals as well. However, it is certainly not clear how corporate sustainability may contribute to the global goal of sustainability. In our paper, several reasons are presented as to why the contribution of the 'mainstream' paradigm of corporate sustainability to macro-level sustainability may be questioned. Convincing arguments can be made that these have to be radically changed in order to reach sustainability. Thus, corporate sustainability – just like sustainability – seems to have a strong social learning character. In such a situation public participation and deliberation have high importance in relation to corporate sustainability. These concepts of community decision-making may also be translated into the level of the organisation through the theory of stakeholder engagement.

After the theoretical analysis of a business's role in sustainability, the potential conflicts between shareholder value goals and corporate sustainability, we discuss stakeholder engagement as a potential tool for corporate sustainability. We also introduce the results of empirical research in Hungary which aims to examine stakeholders' environmental and social claims towards business. It is concluded that it is very unclear in Hungary whether present market circumstances and stakeholder pressures motivate, or even allow, businesses to move towards sustainability. Thus, before placing too much emphasis on stakeholder engagement's role in organisational sustainability it is necessary to analyse its possibilities and shortcomings.

Keywords Corporate sustainability • Hungary • Public participation • Stakeholders • Stakeholder engagement

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1 Introduction

The self-destructive nature of the present socio-economic processes has been well known at least since the publication of the Bruntland Report (1987). The unsustainability of these processes is reinforced today by influential reports like that of the IPCC (2007) and Stern (2006). Even in the light of unsustainability, within the current mainstream economic paradigm it is not necessary to rethink the role of the business sector in society. For shareholder theory the only responsibility of the companies in the market economies of the present is to create shareholder value with legal and fair instruments.

In the last few decades, the legitimacy of the contribution of present corporate practices to sustainability has been the subject of extensive criticism (Shrivastava 1994, Lux 2003), and new concepts have emerged regarding the relationship between business and society. One of these is corporate sustainability. However, there is an extensive scientific debate regarding the criteria of and tools for both micro- and macro-level sustainability. For example, at the macro-level we may distinguish between the antagonistic concepts of weak and strong sustainability (Goodland and Daly 1996), or between the environmental and ecological economic approaches to sustainability (Gowdy and Erickson 2005, Illge and Schwarze 2009).

Based on the aforementioned, this chapter is structured as follows: In Sect. 2 different approaches to corporate sustainability are introduced. The conclusion in Sect. 3 is that public participation and deliberation gain an important role when thinking about corporate sustainability. An introduction is provided about how these concepts of social decision-making may appear at the level of the organisation. Since the latter is strongly connected to stakeholder engagement, in Sect. 4, Hungarian empirical research aiming to map stakeholders' sustainability claims as perceived by the Hungarian ISO 14001 qualified firms is introduced. Section 5 draws conclusions based on the empirical analysis in this chapter.

2 Approaches to Corporate Sustainability

There are conflicting macro-level sustainability paradigms in terms of which the characteristics of the sustainable corporation are debated. At one end of the scale we find the quasi-business as usual approaches e.g. eco-modernisation (Pataki 2009). These claim incremental technological fixes are sufficient to talk about sustainable business. At the other end are 'radical approaches' which demand radical changes from business organisations in order for them to become sustainable[1].

[1]A comprehensive survey of all approaches to corporate sustainability is not offered since there are so many of them: e.g. Green Value Added (Atkinson 2000), Sustainable Value Added (Figge and Hahn 2004, 2005, Hahn et al. 2007), the Heuristic Multi-Criteria Approach to corporate sustainability (Schaltegger and Burritt 2005) or Corporate (Ecological) Footprinting (Lenzen et al. 2003, Penela et al. 2009, Weidmann et al. 2007). The aim is rather to just show that the concept of corporate sustainability is a highly diverse one and uncertainty a pervasive element of it.

A quasi-business as usual approach is that of the World Business Council on Sustainable Development (WBCSD), basically an iteration of the widespread concept of eco-modernisation. It can be considered as the mainstream corporate approach to corporate sustainability (see also Springett 2003). WBCSD is a CEO-led global association of some 200 multinational companies from more than 35 countries and 20 major industrial sectors. It is thus important to analyse the WBCSD's outlook because it is emblematic of the self-interpretation of the corporate sphere regarding sustainability. The WBCSD claims that no radical changes are needed from the business sector in order to reach the state of sustainability (WBCSD 2007). The reason given is that enhancing eco-efficiency and instrumental stakeholder management are both beneficial for the company and its social and natural environment, and thus result in a win-win situation. Hence, it is not necessary to choose between shareholder value maximisation as an ultimate corporate goal and the social goal of sustainability since there is no conflict between them. The logic of this argument is widely criticised on several grounds:

1. The false assumption of an idealised win-win situation regarding the economic and environmental pillars of sustainability
2. The sustainability limits of enhanced eco-efficiency (Alcott 2005)
3. The instrumental treatment of stakeholders (Banerjee 2008, Driscoll and Starik 2004, Fitchett and McDonagh 2000)
4. Its taboos (Kallio 2007), or obsessions and silences (Pataki 2009)[2]

Due to the strength of these critiques different 'radical approaches' to corporate sustainability have emerged. The concept of eco-centric management (Shrivastava 1995) underscores the need for the radical rethinking of the dominant management paradigm and associated corporate management activities, based on the risk-society thesis. In such circumstances the optimisation of production variables is no longer sufficient, and risk variables should also be managed. Therefore, it is necessary to radically rethink the traditional management paradigm, since it was developed for industrial societies. There is a need to re-evaluate the sense of obligation both towards humanity and nature when greening organisational theory (Shrivastava 1994).

An even more radical concept is the nonprofit sustainability thesis (Lux 2003) which recognises modern society is on its way to destroying both the natural and the social world. As a result of the absence of higher motives or principles, the profit motive takes the place of older motives. It becomes the core characteristic of

[2]When analysing and criticising this paradigm the literature of the analysis and critique of the mainstream corporate social responsibility (CSR) discourse and eco-modernisation is drawn on, for two reasons. First, corporate sustainability and CSR definitions are quite convergent (Dahlsrud 2008) which may be a result of the process that even more scholars see business' social responsibility in contributing to sustainability. Second, the characteristics of the WBCSD approach which are analysed and criticised here from the aspect of sustainability – its focus on eco-efficiency, its instrumental relations to stakeholders, its strategic nature, win-win approach and taboos – are also characteristic of the mainstream CSR and eco-modernisation discourse (see e.g. Kallio 2007, Kotler and Lee 2005, Pataki 2009, Springett 2003).

modern society and leads to a society committed to continuous economic growth. At the same time, economy is the part of the eco-system which is closed, finite and non-growing; it consequently cannot have an infinitely growing subsystem. It follows that the traditional economic motive has to be replaced by something else in order to create a new, sustainable economy. This requires new institutional structures, e.g. a maximum wage that is a ratio of the minimum wage, and the statutory transformation of all companies into non-profits. With this change – particularly different motivations – put into practice, entrepreneurship activity and technological change are conditioned only or primarily by environmental or the public interest, and thus lead to sustainability.

3 Corporate Sustainability, Deliberation, Participation and Stakeholders

Several conclusions may be drawn based on the above concepts regarding the criteria of corporate sustainability. *First*, different scientific approaches to corporate sustainability are sometimes antagonistic. On one hand is the shareholder value-orientated WBCSD approach. On the other hand alternative corporate sustainability paradigms emphasise that corporate sustainability at some points require companies to choose between the conflicting needs of shareholder value and other stakeholder needs. *Second*, it is possible to raise serious doubt about the positive and sufficient sustainability effects of an incremental correction of the current economic structure, and associated management paradigm and practice. Convincing arguments can be made that these have to be radically changed in order to reach sustainability. In situations demanding social learning, public participation and deliberation seem to be the key relevant factors (Tippet et al. 2005). Because of this, a growing number of authors emphasise the role of deliberation and participation in sustainability at the micro-level of that organisation. That is the reason why stakeholder engagement – instead of pure shareholder thinking – gains attention in relation to corporate sustainability.

Companies may contribute to public participation and deliberation in basically two ways. First, they can themselves participate in influencing certain socioeconomic processes. Since companies are nowadays the major players in shaping consumer preferences and legislation (Michaelis 2003, Stiglitz 2002), they are agents in social decision-making. Although they play quite a contradictory role in this area today, they may involve themselves 'in the development of market frameworks for internationalisation of external effects of business and… through lobbying and other means, increase public awareness of the need for sustainability' (Schaltegger and Burritt 2005). Unfortunately, although this line of thought is very underdeveloped in the literature, the basic idea behind encouraging sustainable legislation seems clear: it may eliminate the contradictions resulting from the voluntary nature of corporate sustainability. These contradictions basically stem from the lack of business accountability towards society (Agle et al. 2008, Brenkert 1992) and opportunistic behaviour (Tilley 2000), two sources that may hypothetically disappear when a unified legal framework is applied.

Second, companies may foster participation and deliberation through stakeholder engagement[3]. The popularity of stakeholder theory can be traced back to the now classic 1984 book of Freeman. Since then 'stakeholder theory evolved from a pure "theory of the firm" into a more comprehensive and diverse research tradition, addressing "the overall stakeholder relationship as a multifaceted, multiobjective, complex phenomenon" from various perspectives' (Steurer et al. 2005:265)[4]. Even though just a short time ago Steurer et al. (2005) stated that stakeholder relationship management[5] and sustainable development are rarely related to each other, since then stakeholder theory has become more closely connected to the concept of sustainability and corporate sustainability. This connection is either explicit or implicit. Several authors (Amaeshi and Crane 2005, Burchell and Cook 2008, Hund et al. 2002, Kaatz et al. 2005, Mathur et al. 2008, Steurer et al. 2005, Van Huijstee and Glasbergen 2008, Wilburn 2009) emphasise the role of stakeholder engagement in corporate sustainability or sustainability, while others (Payne and Calton 2002, 2004, Roloff 2008) examine the concept of (organisational and social) learning in terms of stakeholder engagement. This latter stream of literature is indirectly connected to corporate sustainability, since learning is a process essential for sustainability – see above.

The literature on stakeholder management and sustainability covers a broad range of topics. It aims to determine the optimal stakeholder engagement process and outcomes regarding sustainability. Of course the optimal and 'sustainable' form of participation and deliberation cannot be defined in advance, regardless of the context in which it is used. Nevertheless, this literature tries to define the characteristics of the good practice of participation and deliberation. Its theoretical background can be traced to Habermas' classic theory of communication: the ideal conditions for discourse require equal information among the participants, respect for each perspective, equal distribution of power, and participants who make sincere, honest and accurate arguments with a legitimate basis. Today, a great many other criteria appear in the literature which are regarded as essential for a deliberative process (e.g. stakeholder engagement) to be effective[6], open debate, enough time,

[3]Stakeholder engagement may be defined in a variety of ways. One view of it is as a process that creates a dynamic context of interaction, mutual respect, dialogue and change and not the one-sided management of stakeholders (Amaeshi and Crane 2005). Another view is that it does not require communication to be reciprocal and interactive. Only *stakeholder dialogue* presumes interactive, two-way communication and its stakeholders (Van Huijstee and Glasbergen 2008).

[4]For a comprehensive study of recent research streams in stakeholder thinking see Agle et al. (2008).

[5]Since not stakeholders themselves, but rather relations with them, are managed, the authors use the term "stakeholder relations management" instead of stakeholder management.

[6]Such a process is effective when it provides the theoretical benefits described later in the study.

parties being equally informed, everyone being able to present their opinion and hear other's opinion, inclusion of unconventional (including local cultural) knowledge, focus on understanding the different values instead of managing competing interests, commitment to the deliberative process, providing stakeholders with opportunities to speak without fear, ensuring that opinions are respected, design of arenas accessible to all those with a stake in an issue, transferring power to make decisions close to those stakeholders who will be affected by them (Ameshi and Crane 2005, Mathur et al. 2008, see also Payne and Calton 2002, Van Huijstee and Glasbergen 2008)[7].

Regarding outcomes (stakeholder engagement's instrumental value regarding sustainability), Van Hujistee and Glasbergen (2008) argue that a proactive dialogue stimulates a mutual learning process that spurs creativity and innovation. Thus dialogue is a way to find solutions for complex sustainability problems, helping companies to detect and solve sustainability problems related to their business. Wilburn (2009) shows how stakeholder dialogue can eliminate unintended negative consequences of corporate projects. According to Mathur et al. (2008) an engagement and interaction with a wide range of stakeholders contributes to a positive shift from merely satisfying shareholders' interests to being more responsible towards society. Stakeholder dialogue is thus an invaluable opportunity for social learning.

This genre of literature also makes a distinction between non-sustainable and sustainable stakeholder management. Mathur et al. (2008) distinguish three streams of stakeholder engagement: the strategic management, the ethical and the social learning (see also Payne and Calton 2002)[8]. As long as the strategic management and ethical perspectives are connected to the 'traditional' instrumental-normative dichotomy, the social learning perspective sees stakeholder engagement as a process of dialogue in which both reflection and mutual learning are inherent elements. They conclude all three perspectives are important for sustainability but it is the latter which is probably the most important since stakeholders may learn about each other's values, reflect upon their own and create shared vision and objectives.

[7] The optimal communicative situation is usually traced back to Habermas (see also Dryzek 2000). Van Huijstee and Glasbergen (2008) refer to several other significant scholars regarding this broad topic.

[8] The strategic management approach is utilitarian in nature. It is primarily concerned with the identification of claims, persons, groups or organisations which are important for a company and to whom the management must pay attention. This approach focuses on stakeholders' usefulness for managers in order to improve the performance of the organisation. The ethical perspective considers stakeholders 'as citizens having a right to determine (or at least influence) the services and valuing the process of participation for democratic reasons.' (Mathur et al. 2008:601). For further discussion see the 'traditional' distinction between instrumental and normative stakeholder theory (Agle et al. 2008, Donaldson and Preston 1995, Evan and Freeman 1988, Goodpaster and Matthews 1982). These distinctions also result in different stakeholder definitions (Driscoll and Starik 2004). As long as narrow definitions include stakeholders based on managerial perceptions of stakeholder power, resource dependence or risk (strategic management or instrumental approach), broad definitions in contrast will include any groups or individuals who can significantly affect or be affected by an organisation's activities (ethical or normative approach).

Van Huijstee and Glasbergen (2008) distinguish between two, but not mutually exclusive, dominant perspectives in the stakeholder management literature. Stakeholder dialogue is seen as a sustainability instrument and, the other as a strategic management tool (Table 6.1), but it is the former which has an instrumental value for sustainability because of its learning potential.

Another popular topic, often within the same publications, is the real-world impact of stakeholder dialogue and its challenges. Unfortunately empirical work in this area is scarce (Burchell and Cook 2008, Schaltegger and Burritt 2005,

Table 6.1 Stakeholder influence as perceived by managers[a]

		Stakeholder influence		
Stakeholder group	Stakeholder	*N*	Mean	Std. Dev.
Inner	Owners (if not equivalent with the manager)	62	4.27	1.18
	Employees	77	3.79	1.02
	Family (if there is a manager-owner)	58	2.90	1.67
Local	Local government	77	3.12	1.29
	Local community	77	2.66	1.26
	Local environmental NGOs	75	2.40	1.20
	Local media	77	2.31	1.18
	Local sport and cultural NGOs	75	1.83	1.04
	Local social NGOs (e.g. dealing with marginalised groups)	75	1.79	0.98
	Good personal relationships	77	3.71	1.11
National	National social NGOs (e.g. dealing with marginalised groups)	75	1.49	0.81
	National sport and cultural NGOs	73	1.44	0.88
	Government	77	3.79	1.16
	Industrial associations	76	2.58	1.27
	National environmental NGOs	76	2.39	1.23
	National media	77	2.14	1.16
	Consumer associations	75	2.03	1.17
International	Local offices of international environmental NGOs	73	1.73	1.06
	Local offices of other international NGOs	75	1.63	1.02
Business	Large customers	75	4.01	1.06
	Large suppliers	77	3.39	1.04
	Small customers	74	2.58	1.12
	Small suppliers	76	2.46	1.06

[a] In relation to the question about owners' influence: companies were asked only to answer if the owner was not identical with the manager. In the matter of the question of the family's influence managers were asked to answer only when there was an owner-manager. The fact that there are 62 answers regarding owners and 58 in the case of family influence seems *prima facie* to be contradictory. However, these two categories are not mutually exclusive. For example, there may be persons who answered both questions because they are owner-managers (and thus answered question of family influence) but do not own the company alone (and thus also answer the question regarding owner influence).

Van Huisjtee and Glasbergen 2008) and a full range of conceivable dilemmas can be addressed (Payne and Calton 2004). One clear lesson from this literature is that the optimal communicative situation is extremely difficult to achieve. Payne and Calton (2004) question the real-world effectiveness of dialogic learning, relationship building and business social responsiveness. They suggest that before operationalising communicative rationality it is crucial to recognise how many dilemmas remain unanswered and to explore other potential directions for research on significant forms of multi-stakeholder dialogues (see also Payne and Calton 2002).

Despite all of these difficulties and critiques with regard to sustainability, real-world stakeholder engagement does not seem to be totally ineffective. Van Huijstee and Glaasbergen in their empirical study (2008) of business – non-government organisation (NGO) – dialogues show why these may lead to improved relationships, increased understanding and trust, creation of partnerships, gaining knowledge and expertise possibly leading to the improvement of corporate policies from a sustainability viewpoint, and amendments in planned corporate activities. They conclude that although corporations arrange their stakeholder relationships based on the strategic management approach, the learning processes emerging among the involved individuals might be the added value – in sustainability terms – of stakeholder dialogue.

Another empirical study in the corporate social responsibility (CSR) field by Burchell and Cook (2008) employs qualitative methods to study the process of stakeholder dialogue. They find that dialogue may contribute to intra- and/or interorganisational and individual learning, establishing trust and changing relationships. However, these processes in many cases originate at the individual level, and there remain significant barriers to extending this interpersonal trust into interorganisational trust and understanding.

A third topic is the critical literature on stakeholder engagement and corporate sustainability[9]. Some authors have analysed current practices of companies in relation to stakeholders, the social good and sustainability (Brenkert 1992, Jensen (2008) cited by Agle et al. 2008), and are alarmed that giving too much power to social actors without securing opportunities for their social control may lead to very negative social outcomes. Another set of authors examines the taboos (Kallio 2007), silences or omissions (Pataki 2009) and paradigmatic basis (Springett 2003) of related academic and corporate discourse. A further set of authors clearly articulate stakeholder issues. Some question the theoretical underpinnings of normative/ethical stakeholder management from an organisational theory perspective (Orts and Studler 2002)[10], while others (Banerjee 2008) conclude that in practice the 'stakeholder theory of the firm represents a form of stakeholder colonialism that serves to regulate the behaviour of stakeholders' (Banerjee 2008:51).

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[9]Here reference is not made to the so-called Freeman-Friedman debate (Agle et al. 2008, Friedman 1970) but to the literature emphasising that voluntary corporate action in relation to stakeholders and sustainability may be quite dangerous from a sustainability or well-being point of view.

[10]Other authors (Payne and Calton 2004, Schaltegger and Burritt 2005) do not question the theoretical underpinnings of normative stakeholder management, but still address numerous practical difficulties regarding their real-world application.

A fourth topic in the special literature is the examination of those claims made by different stakeholders towards business in relation to sustainability. In this field there exists little empirical work, with several notable exceptions. Fineman and Clark (1996) use a stakeholder framework to examine industrial responses to green pressures, studying qualitatively the effects of green stakeholders, i.e. campaigners and regulators in four UK industries. They conclude that stakeholders' access to industry is the smoothest when their legitimacy is perceived to be high and their threat low. In such cases their discourse more or less matches that of the industry. Besides, pro-environmental responses are in the main restricted to campaigners and regulators. Eventually, green stakeholders rarely obtain legitimacy solely on the basis of environmental grounds. Their influence is acknowledged only when and where it is expressed through the language of more legitimate interests or in and through irresistible alliances. Céspedes-Lorente et al. (2003) examine the effect of stakeholder pressures on environmental management practices in a quantitative study of the Spanish hotel industry. They conclude that organisational responses to the environmental demands of stakeholders often depend on factors like stakeholders' power and its use to protect the environment, and the perceived economic advantages of environmental management activities. Konrad et al. (2006) – after setting up the theoretical framework (Steurer et al. 2005) – empirically analyse stakeholder pressures and the extent stakeholder relations management can contribute to sustainable development at the corporate level. The authors conclude, based on a quantitative survey among multinationals, that stakeholder relations management indeed promotes sustainable development, but is not a realistic alternative to government regulation.

The empirical research in this study aims to extend to the fourth topic identified above that is the claims made by different stakeholders towards business in relation to sustainability. Stakeholders' sustainability claims among Hungarian ISO 14001 certified enterprises are investigated through an examination of how managers experience sustainability-related stakeholder pressures from their diverse stakeholders. The next section shows the results of the Hungarian empirical investigation, and is followed by a general discussion of their implications for the stakeholder management-sustainability relationship.

4 Sustainable Stakeholder Pressures among Hungarian ISO 14001 Certified Companies

4.1 Method

The research consisted of complimentary qualitative and quantitative phases. The qualitative phase included nine semi-structured interviews with SME managers[11] from the Southern Great Plain Region of Hungary. The three-part interview

[11] SME managers were interviewed because the research also has an exploratory nature regarding stakeholders' sustainability pressures among Hungarian SMEs.

structure in the main was adapted from Matolay et al. (2007). Each manager was asked about the 'narrative story' of the enterprise (its founding, main events in its history, activities, etc.). The second part consisted of a series of questions about their relationship with the main stakeholders (employees, customers, suppliers, government, local government, media, local community, natural environment and future generations) with an emphasis upon the mutual claims made in relation to these groups. In the last part questions were asked more generally about their managerial values.

The quantitative phase included a survey of 77 small to large Hungarian ISO 14001 companies. A random sample of the members of KÖVET-INEM Hungary (www.kovet.hu) was taken and persons in top management of the selected enterprises asked to respond to the questionnaire[12]. The survey was initially developed on the basis of Konrad et al.'s (2006) stakeholder-matrix which aims to map stakeholders' sustainability claims as perceived by the managers of multinationals. The common complaint was noted that the concepts of CSR and corporate sustainability are exceedingly narrow in their focus on large companies, especially multinational corporations, and consequent neglect of the socio-economic role of SMEs (Jenkins 2006). Hence, the stakeholder-matrix methodology based on the small- to medium-sized enterprises (SMEs)-CSR literature (Cambra-Fierro et al. 2008, Fuller and Tian 2006, Jenkins 2004, 2006, Spence et al. 2003, Spence and Schmidpeter 2003, Vives 2006, Vyakarnam et al. 1997) was adapted in order to include questions about corporate sustainability that would be relevant for both large companies and SMEs[13].

The questionnaire consisted of three main parts: First, managers were asked to judge the importance of certain sustainability aspects of the activity of the company[14]. Twenty-six sustainability aspects were determined using the three-pillar approach to sustainability (and these determined the economic, social and environmental aspects of company activities), and then selected based on the mainstream CSR and corporate sustainability literature (www.wbcsd.org, Streuer et al. 2005) and the aforementioned SME-CSR literature. In the second part, different stakeholders were listed and managers asked to judge the extent of their influence on company success[15]. In the third part, three stakeholders (employees, local community and customers) were listed and managers asked to judge how important these stakeholders' claims were for the company in regard to the previously determined 26 sustainability aspects[16]. Managers had to rate the importance of the same sustainability

[12]The list of ISO 14001 qualified companies used for sampling consisted of about 1,100 companies. A database was built through the Internet, and about 800 company e-mail addresses gathered. The questionnaires were sent to these addresses. Data was gathered from 77 companies.

[13]The questionnaire is available on request.

[14]Here a five-grade Likert-scale was used.

[15]A five-grade scale is used here where one meant 'not influential at all' and five meant 'very influential'.

[16]The importance of the claims of stakeholders were measured on a five-grade scale where one meant 'not important at all' and five meant 'very important'.

claims in the case of all three stakeholders. Here because of space limits only the results of the second and third parts of the questionnaire are addressed.

It is also important to emphasise what was not measured in the quantitative research. Since a stakeholder-matrix questionnaire is very demanding of the respondents' time, the authors were precluded from including several themes in their questionnaire. First, questions regarding all three attributes (power, legitimacy and urgency), which taken together lead to stakeholder salience, could not be asked (Agle et al. 1999, Mitchell et al. 1997). The only category used in this respect is stakeholder influence on company success. Second, only three stakeholder groups could be included in the analysis when questioning firms on the importance of stakeholder claims. These were employees, local community and customers who are among the most influential stakeholder groups according to the literature, especially regarding non-economic claims (Konrad et al. 2006) and among SMEs (Jenkins 2006).

Data was purposively elicited using indirect semi-structured interviews and questionnaires. This means expressions like CSR, responsibility or sustainability were not mentioned during the whole research process (only at the very end of the qualitative interviews). There is thus a good chance that participants did not recognise the real goal of the research – namely sustainability pressures coming from stakeholders – until the very end of the research process. A conscious decision was made to minimise the obvious measurement error that otherwise might result, given the political nature (Kallio 2007) of corporate responsibility. A direct questioning about this universe of issues would most probably have caused the revealed preferences to significantly differ from the real preferences.

4.2 Results

Based on the results of the first part of the questionnaire (Table 6.1), it is clear most influential stakeholders and influences are owners, large customers, government, employees and good personal relationships[17]. The perceived influence of the local community is much lower than expected based on the theoretical literature.

Aggregate stakeholder groups based on stakeholder categorisations found in the literature (Konrad et al. 2006) (Fig. 6.1). This classification allows the observation that 'inner stakeholders' on average are those perceived as being the most influential, and that the average perceived stakeholder influence decreases along the local to the global scale. However, there is an exception to this later statement in the case of the national government which is perceived to be more influential than any local stakeholders (Table 6.2).

[17] Good personal relationships are included in the questionnaire because according to Szerb (2003) one of the categories of entrepreneurs is the so-called interpreneur, someone who places strong emphasis on social and communication skills and the ability to co-operate with other network members. These are partly based on informal relationships.

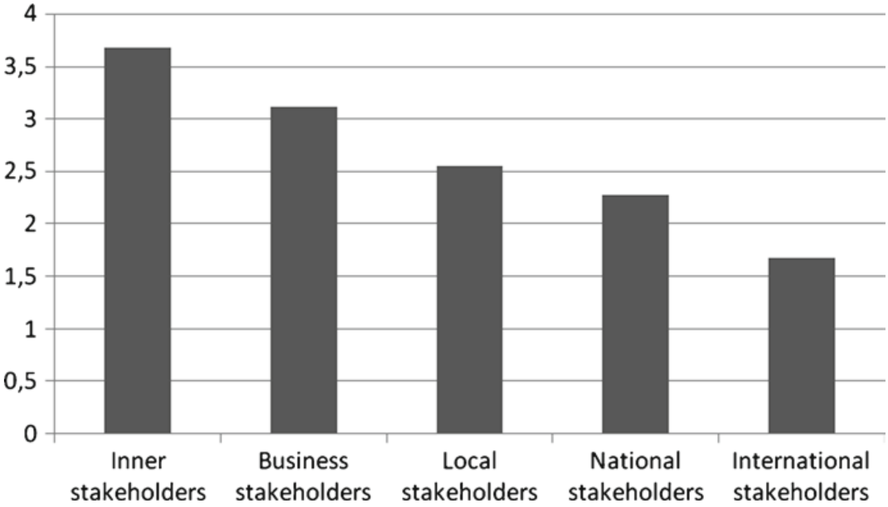

Fig. 6.1 Average influence of different stakeholder groups

Table 6.2 Sustainability claims examined

	Inner/outer expectations		
Sustainability pillars	Inner	Local	National/global
Economic	Economic targets of the company		
Social	Employees	Local community social targets	General social targets
Environmental	Natural environment	Local natural environment	Natural environment

After questioning about stakeholder influence managers were asked about the importance of the claims different stakeholders set for the company. As mentioned above, the needs of only three stakeholder groups were addressed because of the acute time consumption of the applied stakeholder-matrix questionnaire method. Employees, customers and local community were chosen as they are often mentioned in the literature as being influential stakeholders[18]. The local community – while not among the most influential regarding its perceived influence – was included for two important reasons. First, the theoretical literature on SME CSR

[18]When asking the managers about stakeholder influence differentiation was made between large and small customers based on the qualitative experience and preliminary questioning (Table 6.2). However, there was no chance to do the same when asking managers about the sustainability pressures coming from different stakeholder groups because of the aforementioned time limits.

emphasises SMEs' *embedded* nature (Jenkins 2004, 2006) and thus the relevance of the local community regarding their operations[19]. Second, it was simply taken for granted that the local community expresses strong non-economic (social and environmental) sustainability claims towards companies. The premise here is that companies potentially have a high impact on local communities and this impact is not just business but includes social and environmental aspects.

In the questionnaire managers were asked to judge the importance of their perceived claims of the examined stakeholder groups (Fig. 6.2)[20]. Sustainability claims were divided into six categories:

1. The economic targets of the company
2. Employees
3. General social targets
4. Local community social targets
5. Local natural environment
6. National and global natural environment

The usual three-pillar approach to sustainability was applied and inner and external dimensions of corporate sustainability differentiated (EC 2001, Konrad et al. 2006),

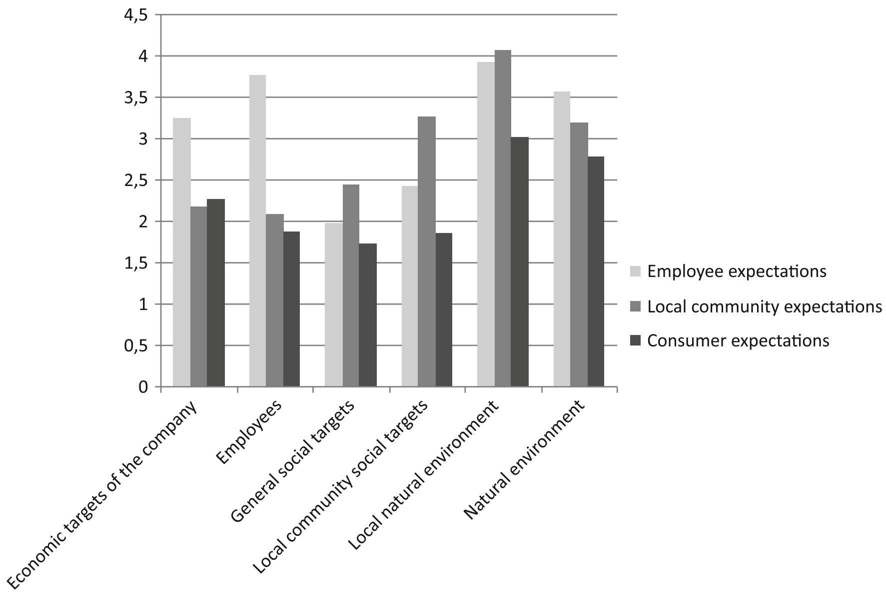

Fig. 6.2 Importance of the claims of the stakeholder groups examined

[19]Note that in the quantitative phase both SMEs and large companies were examined. It was important to create a questionnaire which suits the characteristics of both groups.

[20]For the detailed results see Appendix 6.1.

further distinguishing between local and national/global (Spence and Schmidpeter 2003) in case of the latter (Table 6.2)[21].

Based on the second part of the questionnaire the most influential stakeholders among those examined were found to be customers. Regarding their claims (Fig. 6.2) their average level is the lowest compared to the other two stakeholder groups. Customers' demands are the highest – but still relatively low – in relation to long-run corporate functioning (a category within the economic targets of the company – see Appendix 6.1) and the environmental pillars of sustainability. The relatively low level of customer claims and the relative importance of customers among stakeholders highlight a methodological question to be confronted: it is quite possible that customers do indeed have such important claims towards the firms that the questionnaire entirely fails to cover. This is supported by the qualitative data which shows that, in the case of SMEs, business partners (both customers and suppliers) do have business claims towards the firms interviewed. The most frequently mentioned claims were expressed in terms such as 'proper quality' and 'qualification' (mentioned by seven of the nine interviewed managers), 'punctuality and keeping deadlines regarding fulfilment and payment' (five mentions), 'cooperation' (three mentions) and 'cheapness and proper prices' (three mentions).

Employees are also perceived as important stakeholders (Table 6.2). Their most important claims (Appendix 6.1) show employees most of all expect the company to secure long-run employment for them (this claim is the most important within the dimension of 'employees' with an average value of 4.81). Managers also perceive claims from the employees regarding environmental protection, but these are weaker than those regarding long-run employment. Furthermore, employees hardly require their company to be socially active. These results are also reinforced by the qualitative interviews among SMEs. Here it was found that to the indirect question managers did not mention any environmental or social claims coming from employees but only 'economic' ones. These were unanimously providing long-term employment and fair annually rising wages guaranteeing material security.

The least important stakeholder examined is the local community. It makes demands first of all in relation to the environmental and local social pillars of sustainability (Appendix 6.1), most of all locally (Fig. 6.2). The perceived scope of the claims of the local community is generally narrower than of employees, but this may in part be the result of the absence of reference to certain claims of the local community in the questionnaire. The qualitative data reveals two such potential claims, at least in the case of SMEs. These are the proper payment of local taxes (a claim of the local government) and quality work (a claim of local people such as customers); both issues were often spontaneously mentioned in the interviews. Nevertheless, it is logical to assume the local community indeed has lower-level requirements regarding the firms relative to the employees.

[21] As can be seen in Table 6.2, the dimension of 'natural environment' appears both as an inner and a national/global claim. The reason is that in the case of several items aiming to measure this dimension, the questionnaire is not suitable for deciding whether they belong to the inner (e.g. cost efficiency) or external (e.g. reducing greenhouse gas effect) dimension. Such typical items are energy reduction, waste reduction or recycling.

5 Conclusions

In the theoretical overview above it is argued that because of social incommensurability and the need for social learning, stakeholder engagement plays an important role in corporate sustainability. However, as can be seen from the empirical research, Hungarian ISO 14001 qualified enterprises meet manifold stakeholder claims. Managers perceive that influential stakeholders (both employees and customers) mainly require sound economic performance from the firm, and to a far lesser degree, environmentally and socially conscious activities[22]. It appears that companies which operate based on stakeholder claims may not thereby be led to go in an environmentally and socially conscious direction but rather in an economic-driven one. Therefore, meeting stakeholder demands may not lead towards the realisation of the 'classic' goals of sustainability. In general, stakeholder relationship management in itself does not necessarily have an instrumental value regarding sustainability.

These findings have several implications. First, stakeholder engagement (or public participation and deliberation) in itself does not necessarily result in a potential move towards sustainability. Rather, it is potentially a certain kind of stakeholder engagement. Although the quality of stakeholder relationships were not analysed (the analysis is static and does not deal with the process of stakeholder engagement and its outcomes, e.g. organisational or social learning), it is assumed that they may be far from the processes which are upheld as ideal in the special literature. Thus, one vital direction for fruitful future research should be *how* stakeholder engagement may contribute to sustainability.

Second, when connecting the concept of stakeholder engagement with sustainability, it always has to be kept in mind that the circumstances in which certain stakeholders live and operate determine the way they act[23]. This means they may live in a socio-economic system within which it is rational to have needs towards each other which are judged 'unsustainable' based on classic sustainability criteria. In the case of the South Great Plain Region of Hungary, where we conducted our qualitative study, most interviewed SMEs felt their, and thus their employees' and competitors', existential situation was very uncertain, even for the short-run. It is natural to assume that in an existentially insecure position social agents are

[22] It is again stressed that only managerial perceptions were examined. Since there can be a gap between managerial perceptions and real stakeholder demands (the way stakeholders see their own needs), the results do not necessarily mean that operating based on real (and not perceived) stakeholder interest can in itself prevent making a move towards sustainability in general. However, according to Fineman and Clarke (1996) stakeholder claims do indeed gain legitimacy through managerial perceptions.

[23] Although neoclassical economics basically sees preferences as exogenous, in the modern paradigm of old institutional economics preferences are endogenous to socio-economic circumstances and change. The latter view is supported by many scientific facts but the former is not (Vatn 2006).

going to prioritise economic needs ahead of environmental and social ones. This is not to say that every stakeholder claim necessarily points in an unsustainable direction but there is clearly a possibility that such a phenomenon may be experienced in the case of many stakeholders and many of their claims. Thus, the study suggests it is always important to analyse the socio-economic system in which companies and their stakeholders operate. That is the background that is going to determine their needs and activities and thus determine stakeholder engagement's sustainability capacity.

Eventually the opportunities provided for, and limits set in front of, stakeholder management's contribution to sustainability in capitalist societies are other important future research areas. Although this research examines and only holds for Hungary in the case of a given sample, similar research in other capitalist countries on other business populations show somewhat similar results (Fineman and Clark 1996, Konrad et al. 2006). These indicate that economic pressures are those which are at the core of the present forms of western capitalist economic systems characterised by such key features as limited responsibility and globally free flow of capital[24].

Appendix 6.1 The importance of the sustainability claims of certain stakeholders (employees, local community and consumers)

	Employee claims			Local community claims			Consumer claims		
	N	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Mean	Std. Dev.
Contributing to the solution of global environmental problems	69	3.06	1.22	63	3.05	1.16	62	2.94	1.29
Energy reduction	70	3.59	1.23	64	3.03	1.32	63	2.59	1.36
Protecting national natural environment	69	3.68	1.06	64	3.63	1.15	62	3.06	1.21
Recycling and selling by-products	66	3.56	1.17	60	3.02	1.40	59	2.54	1.34
Recycling and selling waste	66	3.71	1.13	60	3.12	1.38	59	2.83	1.38
Waste reduction	69	3.81	1.00	64	3.38	1.34	62	2.74	1.35
Protecting local natural environment	70	3.93	0.86	65	4.08	1.02	64	3.02	1.19
Corresponding to local community norms/values	71	3.24	1.06	67	3.70	1.11	66	2.36	1.15

(continued)

[24]The fact that it is the instrumental form of stakeholder management is the one that is dominant in practice; this assumption has further support (see Agle et al. 1999, Banerjee 2008, Céspedes-Lorente et al. 2003, Fineman and Clarke 1996, WBCSD 2006).

Appendix 6.1 (continued)

	Employee claims			Local community claims			Consumer claims		
	N	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Mean	Std. Dev.
Employing the disadvantaged members of the local community	70	2.10	0.92	66	3.23	1.26	66	1.77	0.99
Doing something for the local community above its expectations	67	2.34	1.05	63	3.51	1.23	62	1.87	1.03
Motivate employees to do voluntary work for local community goals	70	1.93	0.98	65	2.98	1.19	65	1.66	0.94
Reducing local income inequities	65	2.63	1.33	60	2.53	1.24	59	1.76	1.16
Supporting local sport, cultural and religious organisations	71	2.30	1.13	67	3.55	1.12	65	1.65	0.96
Supporting national sport, cultural and religious organisations	70	1.90	1.04	63	2.41	1.20	63	1.57	0.84
Supporting the disadvantaged people/groups of the country	68	1.87	0.94	63	2.40	1.11	63	1.57	0.86
The voluntary work of corporate managers supporting national social goals	69	2.19	1.14	64	2.55	1.22	64	2.03	1.21
Flexible work time for the employees	73	3.47	1.11	66	1.52	0.90	65	1.77	1.16
Providing secure, long-run employment for the employees	73	4.81	0.40	68	3.18	1.35	66	2.30	1.34
Reducing income inequity within the firm	73	3.53	1.03	67	1.96	1.13	65	1.49	0.87
Securing employee education	72	3.78	1.01	66	2.20	1.19	67	2.43	1.26
Securing participation opportunity to corporate decisions	73	3.15	0.94	67	1.79	0.98	67	1.64	1.04
Small favours for the employees	73	3.88	0.93	67	1.84	1.11	67	1.55	0.91
Increasing company profit from year to year	73	3.47	1.12	70	2.01	1.19	68	2.13	1.29
Pass the company down to next generations of family (in case of family business)	50	2.26	1.38	47	1.62	0.97	47	1.74	1.22
Securing the long-run existence of the business	73	4.53	0.82	68	3.18	1.44	68	3.29	1.35
Securing the long-run well-being of the owners	70	2.37	1.25	67	1.70	1.03	68	1.71	1.05

References

Agle BR, Mitchell RK and Sonnenfeld JA (1999) Who matters to CEOs? An investigation of stakeholder attributes and salience, corporate performance, and CEO values *Academy of Management Journal* 42.5 507–525

Agle BR, Donaldson T, Freeman RE, Jensen MC, Mitchell RK and Wood DJ (2008) Dialogue: Toward superior stakeholder theory *Business Ethics Quarterly* 18.2 153–190

Alcott B (2005) Jevons' paradox *Ecological economics* 54 9–21

Amaeshi KM and Crane A (2005) *Stakeholder Engagement: A Mechanism for Sustainable Aviation* SSRN Working Paper Series [online] Available from Internet URL <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=763464>

Atkinson G (2000) Measuring corporate sustainability *Journal of Environmental Planning and Management* 43.2 235–252

Banerjee SB (2008) Corporate social responsibility: The good, the bad and the ugly *Critical Sociology* 34.1 51–79

Brenkert GB (1992) Private corporations and public welfare *Public Affairs Quarterly* 6 155–168

Bruntland GH (1987) *Our Common Future: The World Commission on Environment and Development* Oxford, Oxford University Press

Burchell J and Cook J (2008) Stakeholder dialogue and organisational learning: Changing relationships between companies and NGOs *Business Ethics: A European Review* 17.1 35–46

Cambra-Fierro J, Hart S and Polo-Redondo Y (2008) Environmental respect: Ethics or simply business? A study in the small and medium enterprise (SME) context *Journal of Business Ethics* 82.3 645–656

Cespedes-Lorente J, Burgos-Jimenez J and Alvarez-Gil MJ (2003) Stakeholders' environmental influence. An empirical analysis in the Spanish hotel industry *Scandinavian Journal of Management* 19.3 333–358

Dahlsrud A (2008) How corporate social responsibility is defined: An analysis of 37 definitions *Corporate Social Responsibility and Environmental Management* 15 1–13

Donaldson T and Preston LE (1995) The stakeholder theory of the corporation: Concepts, evidence, and implications *Academy of Management Review* 20.1 65–91

Driscoll C and Starik M (2004) The primordial stakeholder: Advancing the conceptual consideration of stakeholder status for the natural environment *Journal of Business Ethics* 49.1 55–73

Dryzek J S (2000) *Deliberative Democracy and Beyond: Liberals, Critics, Contestations* Oxford, Oxford University Press

EC (2001) *Promoting a European Framework for Corporate Social Responsibility – Green Paper* Office for Official Publications of the European Union [online] Available from Internet URL <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2001:0366:FIN:EN:PDF>

Evan WM and Freeman RE (1988) A stakeholder theory of the modern corporation: Kantian capitalism *in* Beauchamp T and Bowie N Ethical Theory and Business Englewood Cliffs, Prentice Hall 75–93

Figge F and Hahn T (2004) Sustainable value added: measuring corporate contributions to sustainability beyond eco-efficiency *Ecological Economics* 48.2 173–187

Figge F and Hahn T (2005) The cost of sustainability capital and the creation of sustainable value by companies *Journal of Industrial Ecology* 9.4 47–58

Fineman S and Clarke K (1996) Green stakeholders: Industry interpretation and response *Journal of Management Studies* 33.6 715–730

Fitchett JA and McDonagh P (2000) A citizen's critique of relationship marketing in risk society *Journal of Strategic Marketing* 8.2 209–222

Friedman M (1970) The social responsibility of business is to increase its profits *New York Times Magazine* September 13 32–33

Fuller T and Tian Y (2006) Social and symbolic capital and responsible entrepreneurship: An empirical investigation of SME narratives *Journal of Business Ethics* 67.3 287–304

Goodland R and Daly H (1996) Environmental sustainability: Universal and non-negotiable *Ecological Applications* 6.4 1002–1017 (available only in Hungarian)
Goodpaster KE and Matthews GB (1982) Can a corporation have a conscience? *Harvard Business Review* (January–February) 132–141
Gowdy JM and Erickson JD (2005) The approach of ecological economics *Cambridge Journal of Economics* 29 207–222
Hahn T, Figge F and Barkemeyer R (2007) Sustainable value creation among companies in the manufacturing sector *International Journal of Environmental Technology and Management* 7.5/6 496–512
Hund GJ, Engel-Cox JA, Fowler KM and Klee H (2002) Two-way responsibility: The role of industry and its stakeholders in working towards sustainable development *in* Andriof J, Waddock S, Husted B and Sutherland S *Unfolding Stakeholder Thinking* Sheffield, Greenleaf 218–231
Illge L and Schwarze R (2009) A matter of opinion – How ecological and neoclassical environmental economists and think about sustainability and economics *Ecological Economics* 68.3 594–604
IPCC (2007) *The Physical Science Basis Summary for Policymakers* [online] Available from Internet URL <http://www.ipcc.ch/>
Jenkins H (2004) A critique of conventional CSR theory: An SME perspective *Journal of General Management* 29.4 37–57
Jenkins H (2006) Small business champions for corporate social responsibility *Journal of Business Ethics* 67.3 241–256
Kaatz E, Root D and Bowen P (2005) Broadening project participation through a modified building sustainability assessment *Building Research and Information* 33.5 441–454
Kallio T (2007) Taboos in corporate social responsibility discourse *Journal of Business Ethics* 74.2 165–175
Konrad A, Steurer R, Langer ME and Martinuzzi A (2006) Empirical findings on business–society relations in Europe *Journal of Business Ethics* 63.1 89–105
Kotler P and Lee N (2005) *Corporate Social Responsibility: Doing the Most Good for Your Company and Your Cause* New York, John Wiley & Sons
Lenzen M, Lundie S, Bransgrove G, Charet L and Sack F (2003) Assessing the ecological footprint of a large metropolitan water supplier: Lessons for water management and planning towards sustainability *Journal of Environmental Planning and Management* 46.1 113–141
Lux K (2003) The failure of the profit motive *Ecological Economics* 44.1 1–9
Mathur VN, Price ADF and Austin S (2008) Conceptualizing stakeholder engagement in the context of sustainability and its assessment *Construction Management and Economics* 26.6 601–609
Matolay R, Petheő Á and Pataki Gy (2007) *Vállalatok társadalmi felelőssége és a kis- és középvállalatok* Budapest, Nemzeti ILO Tanács (available only in Hungarian)
Michaelis L (2003) The role of business in sustainable consumption *Journal of Cleaner Production* 11.8 915–921
Mitchell RK, Agle BR and Wood DJ (1997) Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts *Academy of Management Review* 22.4 853–886
Orts EW and Strudler A (2002) The ethical and environmental limits of stakeholder theory *Business Ethic Quarterly* 12.2 215–233
Pataki Gy (2009) Ecological modernization as a paradigm of corporate sustainability *Sustainable Development* 17.2 82–91
Payne SL and Calton JM (2002) Towards a managerial practice of stakeholder engagement *in* Andriof J, Waddock S, Husted B and Sutherland S *Unfolding Stakeholder Thinking* Sheffield, Greenleaf 121–135
Payne SL and Calton JM (2004) Exploring research potentials and applications for multi-stakeholder learning dialogues *Journal of Business Ethics* 55.1 71–78

Penela AC, García-Negro MC and Quesada JLD (2009) A methodological proposal for corporate carbon footprint and its application to a wine-producing company in Galicia, Spain *Sustainability* 1 302–318

Roloff J (2008) Learning from multi-stakeholder networks: Issue-focussed stakeholder management *Journal of Business Ethics* 82.1 233–250

Schaltegger S and Burritt R (2005) Corporate sustainability *in* Folmer H and Tietenberg T *The International Yearbook of Environmental and Resource Economics* Cheltenham, Edward Elgar 185–232

Shrivastava P (1994) Castrated environment: Greening organisational studies *Organisation Studies* 15.5 705–726

Shrivastava P (1995) Ecocentric management for a risk society *Academy of Management Review* 20.1 118–137

Spence LJ and Schmidpeter R (2003) SMEs, social capital and the common good *Journal of Business Ethics* 45.1/2 93–108

Spence LJ, Schmidpeter R and Habisch A (2003) Assessing social capital: Small and medium sized enterprises in Germany and the UK *Journal of Business Ethics* 47.1 17–29

Springett D (2003) Business conceptions of sustainable development: A perspective from critical theory *Business Strategy and the Environment* 12.2 71–86

Stern N (2006) *Stern Review on the Economics of Climate Change* [online] Available from Internet URL <http://apo.org.au/research/stern-review-economics-climate-change>

Steurer R, Langer ME, Konrad A and Martinuzzi A (2005) Corporations, stakeholders and sustainable development I: A theoretical exploration of business–society relations *Journal of Business Ethics* 61.3 263–281

Stiglitz J (2002) *Globalization and Its Discontents* New York, WW Norton & Company

Szerb L (2003) The changing role of entrepreneurship in network organisation *in* Lengyel I *Knowledge Transfer, Small and Medium-Sized Enterprises, and Regional Development in Hungary* Szeged, JATE Press 81–95

Tilley F (2000) Small firm environmental ethics: How deep do they go? *Business Ethics: A European Review* 9.1 31–41

Tippett J, Searle B, Pahl-Wostl C and Rees Y (2005) Social learning in public participation in river basin management – Early findings from HarmoniCOP European case studies *Environmental Science & Policy* 8.3 287–299

Van Huijstee M and Glasbergen P (2008) The practice of stakeholder dialogue between multinationals and NGOs *Corporate Social Responsibility and Environmental Management* 15.5 298–310

Vatn A (2006) *Institutions ISEE Internet Encyclopedia of Ecological Economics* [online] Available from Internet URL <http://www.ecoeco.org/pdf/Institutions_Arild_Vatn.pdf>

Vives A (2006) Social and environmental responsibility in small and medium enterprises in Latin America *Journal of Corporate Citizenship* 21 39–50

Vyakarnam S, Bailey A, Myers A and Burett D (1997) Towards an understanding of ethical behavior in small firms *Journal of Business Ethics* 16.15 1625–1636

WBCSD (2007) *The Role of Business in Tomorrow's Society. The Business Role Focus Area I Geneva Dialogue* [online] Available from Internet URL <http://www.wbcsd.org/DocRoot/u4RPYtlMPV9TeijDOmlj/GenevaDialogue.pdf>

Wiedmann T, Barret J and Lenzen M (2007) *Companies on the Scale: Comparing and Benchmarking the Footprints of Businesses* Working paper presented at the International Ecological Footprint Conference Cardiff, Wales [online] Available from Internet URL <http://www.brass.cf.ac.uk/uploads/Wiedmann_et_al_P36.pdf>

Wilburn K (2009) A model for partnering with not-for-profits to develop socially responsible businesses in a global environment *Journal of Business Ethics* 85.s1 111–120

Chapter 7
Corporate Social Responsibility and Competitiveness – Empirical Results and Future Challenges

Torsti Loikkanen and Kirsi Hyytinen

Abstract Globalisation has boosted the demand for a more transparent accounting of corporate responsibilities encompassing social, economic and environmental dimensions. Proactive companies search for competitive advantage in markets by differentiating themselves from competitors. One way to do this is to engage in corporate social responsibility. This trend raises the issues of whether any connection between corporate social responsibility and competitiveness exists or even whether engagement in corporate social responsibility contributes to competitiveness. On the basis of an empirical study this article discusses the connections between corporate social responsibility and competitiveness of Finnish firms. The study by VTT and TKK Dipoli explored this connection from the following angles: first, how companies take into account corporate social responsibility requirements of stakeholders, second, how corporate social responsibility requirements guide business activities and decision making of companies and, third, whether and how socially responsible actions enhance firms' competitiveness. The empirical study consists of case studies in companies identified to be leaders in corporate social responsibility and of a company survey with 150 respondents. As with several other studies, this study also provides support to the existence of a positive connection between corporate social responsibility and competitiveness. The chapter discusses the results of the study and identifies implications, recommendations and proposals for further research on corporate social responsibility and environmental management accounting.

Keywords Sustainable development • Corporate social responsibility (CSR) • Accounting • Transparency • Competitive advantage • Indicators

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1 Introduction

Corporate social responsibility (CSR) is of growing importance for enterprises. Besides the driving forces of CSR, such as increased interest of shareholders in transparent accounting practices of enterprises, related flagrant malpractice examples like Enron's case in the United States, the related and increasingly revealing role of media in CSR issues, and the impacts of these all on consumer behaviour, the current globalisation trend will make CSR even more important in the future. CSR has gradually become a visible function of enterprises and an important element of their strategies, management and leadership, internal and external communication, shareholder and stakeholder relations. However, the importance and weight of CSR issues vary between companies depending on their industrial branches, size, location and geographical location of their markets. Accordingly, companies differ in their strategies and responses to CSR. Some reactive companies may take these issues as challenges for the future, but proactive companies search for competitive advantage by differentiating themselves from competitors by engaging in CSR.

The key issue with respect to CSR is its relationship and possible impacts on the competitive advantage of companies. The corollary questions are whether there exists a connection between CSR and competitiveness and whether CSR contributes to competitiveness of enterprises. This is the point of departure of this chapter. The chapter is about the main results of a recent empirical study of different aspects of CSR on firms' competitiveness and the implications arising for the development of CSR-related accounting. The VTT[1] and TKK Dipoli[2] study (the 'VTT study') explored the connection between CSR and competitiveness of Finnish companies from different angles.

The main questions of the study are:

1. How do companies take into account CSR requirements of stakeholders?
2. How do CSR requirements guide business activities and decision making of companies?
3. Whether and how socially responsible actions enhance firms' competitiveness?

The VTT study is based on four case studies and a company survey and it provides empirical evidence of the existence of a positive connection between CSR and competitiveness in Finnish companies. The study produced several interesting findings, which are discussed in greater detail in this chapter. On the basis of the findings of the VTT study, the chapter identifies some implications arising for environmental management accounting.

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[1] VTT, Technical Research Centre of Finland, is one of the largest research and technology organisations in Europe.

[2] TKK Dipoli, Lifelong Learning Institute of Dipoli, operates as a part of Helsinki University of Technology (since 1 January, Aalto University) in Espoo, Finland.

2 Perspectives on CSR and Competitive Advantage

The context of this chapter is the concept of sustainable development with its three dimensions of responsibility: economic, social and environmental. These dimensions of responsibility together constitute an inseparable and interdependent entity, and they are all dependent on human behaviour, as has been accentuated by the Global Reporting Initiative (GRI) and Sustainability Reporting Guidelines G3 (GRI 2008). Accordingly, in the VTT study CSR is interpreted as a concept (cf. Dentchev 2009) which pulls together three responsibility dimensions of sustainable development. The contents and importance of the three dimensions as well as their mutual weight in enterprise strategies and operations vary depending on numerous factors, e.g. customers, stakeholders, location of markets and cultural aspects.

Numerous organisations publish different financial, environmental or, with respect to content, more extensive reports of sustainability. Increasingly corporations have begun to publish a single annual report including financial, economic, environmental and social information. Financial and sustainability reporting serve parallel and essential functions that enrich each other (GRI 2008). The GRI encourages coordination of the reporting processes and expects that over time financial performance measurement will increasingly benefit from the measurement of economic, environmental and social performance.

Factors driving and motivating earlier development of CSR in enterprises were related to government regulation, but nowadays, there is much self-regulation with signals from markets and customer and consumer behaviour (see Habisch and Jonker 2005, Loikkanen et al. 2007). The development of current CSR grew from the environmental dimension and, since the conceptual contributions of the Bruntland Commission, has broadened to cover three dimensions of sustainable development, i.e. social, economic and environmental (cf. Banerjee 2008, Montiel 2008). In spite of this expansion, environmental aspects dominated companies' responsibility activities until the 1990s. The 1990s brought new 'proactive' aspects to the discussion. The need to solve growing environmental problems was manifested in the importance of commercial opportunities in environmental technology and the related proactive role of company strategies towards innovation-based competitive advantage (Porter and van deer Linde 1996). Also the role of ethical investments, as related to CSR, increased in importance in the late 1990s (Eurosif 2008, Schmidheiny et al. 1998). In the early 2000s, interest in broader CSR aspects, especially with respect to enterprise accounting practices, was boosted by the visibility of malpractices of the Enron Corporation leading to not only the biggest bankruptcy in the United States history, but also revisions of accounting principles and practices as well as related transparency rules. The importance of CSR reporting is increasing because of globalisation and regulation of markets and is expected increasingly to influence responsible behaviour of enterprises (e.g. Roberts 2003).

The drivers and pressures for CSR, i.e. a license to operate, come from government regulation and markets as described above. The more CSR procedures are applied in companies worldwide the sooner they will become part of conventional company practices, which increases the impacts of CSR on global competitive advantage. Studies of the impacts of CSR on competitive advantage are however, if no longer scarce, still very scattered. Margolis and Walsh (2001) carry out a thorough study of the literature over 30 years of academic research on the link between financial and social performance. They conclude that a positive relationship exists between social performance and financial performance but this conclusion must be treated with caution. Serious methodological concerns have been raised about many of the studies and about efforts to aggregate these results. Hesitations relate to: the connection between the underlying corporate social performance (CSP) construct and efforts to measure it; the validity of the measures used to assess social performance; the diversity of measures used to assess financial performance; and the direction and mechanisms of causation, given the heavy reliance on correlation analyses and contemporaneous financial and social performance data (see also Lankoski 2009). In the same spirit Talvio and Välimaa (2004), on the basis of several empirical cases surveyed, conclude that in a multi-dimensional business the identification of a pure cause–effect relationship between CSR and financial performance is difficult even though there appears to be a variety of connections. In global businesses the links and relationships between CSR and economic performance may become even more complicated. CSR requirements will extend from single enterprises to suppliers and logistic chains across national borders. Accordingly an "extended" or "shared" producer's responsibility or "product stewardship" has developed on the basis of life cycle thinking (Crul and Schnitzer 1998).

Competitive advantage of companies in global markets today depends largely on the ability to benefit from knowledge and innovation. In the context of CSR the early hypotheses of Porter and van der Linde (1996) on the importance of environmental issues to future competitiveness of companies are still of relevance in spite of the fact that their original contribution only discussed environmental issues. According to their conclusion, the way an industry responds to environmental problems may in fact be a leading indicator of its overall competitiveness. In addition, a competitive industry is more likely to take up a new standard as a challenge and respond to it with innovation. Porter and van der Linde (1996) also propose regulation designed with six characteristics as a trigger for innovation. First, regulations may signal companies about resource inefficiencies and potential technological improvements. Second, regulation focused on information gathering can achieve major benefits by raising corporate awareness. Third, regulation reduces the uncertainty that investments to address the environment will be valuable. Fourth, regulation creates pressure that motivates innovation. Fifth, regulation levels the transitional playing field. Sixth, regulation is needed in the case of incomplete offsets. The approach of Porter and van der Linde (1996) stimulated an extensive and continuing discussion on "greening competition" which led to further studies on the links between a proactive environmental approach and competitive advantage (Hongisto et al. 2001, Kuisma 2004, Maxwell et al. 1997, Nehrt 1998). One important element of competitive advantage, which gets support from many studies, is the ability of a company to foresee proactively the future trends of both regulation and of consumer tastes in order to make "right" choices and priorities for business development in the long term (Hongisto et al. 2001).

The perspectives on and analyses of CSR and competitive advantage, as referred to briefly above, constitute the background for the VTT study on these issues, which is subsequently discussed in greater detail.

3 Methodology

The VTT study explored the connection between CSR and competitiveness of Finnish companies from different angles. The key questions explored were (1) how companies take into account CSR requirements of stakeholders, (2) how CSR requirements guide business activities and decision making of companies and (3) whether and how socially responsible actions enhance firms' competitiveness. The review consisted of four case studies in companies identified as leaders in CSR, and a survey study based on 150 company respondents (over 40 percent response rate). Case study firms were selected by the following features typical for forerunner companies (Harris and Crane 2002): implementation capacity, innovativeness, reporting that means transparency in their operations, and stakeholder cooperation.

The aim of each case study was to produce knowledge about the state and objectives of CSR. The novelty value of the VTT study was in exploring knowledge creation related to the implementation of CSR. Accordingly one of the main goals of the study was to identify the factors that enhance or hinder the implementation of the CSR principles in case firms. Studies were carried out by interviewing twenty seven executive level representatives of the case firms. The method used in most case studies was the *focus group interview*. The interviews focussed on the following issues:

- CSR concept applied in firms' business activities;
- Operational environment and stakeholder cooperation as a part of CSR in case firms;
- The main strategic and operative goals related to CSR;
- CSR as a part of firm's strategy and practices;
- Relationship of CSR and firm's competitiveness; and
- Future challenges related to CSR in case firms.

The framework and survey were developed on the basis of the results of case studies. The survey was executed as a semi-structured internet questionnaire in collaboration with VTT and Taloustutkimus Ltd (a market survey institute). The company sample was based on VTT's survey research files and on the members of Finnish Business and Society (FiBS), a Finnish network for responsible businesses. The company sample consisted first of 750 company representatives of 350 companies and their operational plants. Company representatives were invited to participate in the study by e-mails, and the final number of respondents was 142, i.e. about 40% of respondents contacted. The responses were analysed using T-tests. The semi-structured internet survey is presented in Appendix 7.1.

Table 7.1 reports the company background of the survey respondents by company size (number of employees and turnover).

Table 7.2 reports the manufacturing and service sectors of the respondents.

Table 7.3 reports the distribution of the professional positions of respondents in companies.

The following section contains analysis of the key results from the case studies and the survey first compiled under sub-titles and then presented in greater detail.

Table 7.1 Company background of the survey respondents (n = 142)

	Turnover %		
Number of employees	>40 m	40 m <	%
> 10	6.3	–	7.0
10–49	13.4	–	14.1
50–249	8.5	2.1	11.9
250–499	1.4	7.0	9.0
500 <	4.9	48.6	54.0
other		7.8	4.0
Total			100.0

Table 7.2 The manufacturing and service sectors of the respondents (n = 142)

Branch of industry		%
Manufacturing	Metal	20.4
	Forest	7.7
	Chemistry	12.7
	Food	4.9
	Other manufacturing	10,5
Services	Construction	7.7
	Business	24.6
	Other services	2.1
Other/no answer		9.4
Total		100.0

Table 7.3 The distribution of the professional positions of respondents in companies (n = 142)

Position	%
Chief executive officers	23.0
Directors of unit or operation	44.0
Communication or PR directors or managers	13.0
CSR directors or managers	8.0
Directors or managers of environmental policy	6.0
Other position of companies	7.0
Total	100.0

4 Results of Interviews and Survey

4.1 General Findings

CSR has expanded with the establishment of the concept of sustainable development and the related introduction of quality and environmental management. Large international corporations with sophisticated environmental and quality management systems also seem to be active in CSR. The importance of CSR has increased gradually and unevenly among companies, and differences exist in CSR policies and procedures, guiding and driving factors, impacts of internal and external factors, impacts on competitiveness and definitions applied. CSR is not an important and targeted issue for all companies; the awareness of CSR varies, and moreover, it is difficult to predict the pace of CSR awareness raising in the future. One conclusion of the case interviews executed in forerunner companies is that CSR procedures are strongly based on earlier procedures and definitions of environmental management which is now becoming more balanced with other dimensions of sustainable development.

The survey examined the importance of different dimensions of sustainable development. Companies rank all dimensions of sustainable development as being important, but the mutual ranking of the dimensions proved to be interesting even though unexpected. The societal dimension was assessed to be most important, the economic dimension second and environmental aspects third in importance. This result, based on company self-assessment, can be seen as an important indication of the growing significance of social aspects at the company level.

The study indicates that the establishment of CSR within the organisation requires a continuous development of competencies of staff which have to be encouraged by persistent management and supporting spontaneous initiatives. One criterion in the distribution of responsibility is the commitment of executives to promote workings also through personal examples. In the forerunner companies, the development of CSR is based strongly on the values introduced and adopted by the company. On the other hand the process of implementing the CSR values is important because in this the company strives to embed responsibility into the whole organisation. CSR-related definitions and concepts and their standardisation (see Dentchev 2009) are still in the early phase of development in companies. In forerunner companies interviewed priority in the realisation of responsibility is in how it disseminates through practical activities to internal procedures and practices.

4.2 Response of Companies to Stakeholders' CSR Requirements

Opinion surveys among customers and stakeholders of companies of CSR were reconfirmed to be rare with the exception of interviewed forerunner companies. In many companies, CSR-related data are collected as a part of customer and stakeholder surveys and events. Interestingly, according to the companies' own assessments, their central stakeholder group is their own personnel. The opinions and expectations of their own staff are examined e.g. by personal development discussions and job satisfaction surveys.

In interviews, forerunner companies' collaboration with stakeholders was found to be more systematic than in other firms. Forerunner companies seem to be more active than others also in the proactive analysis of their functional environment and this is recognised as an important part of their CSR development. In the forerunner companies, the monitoring of expectations of stakeholders and the foresight of changes in their business environment are important elements in the formulation and building of their strategies and policies. One special characteristic of forerunner companies is that an essential part of the development of responsibility is the ability to observe and respond to challenges arising in their functional environment. The dialogue with stakeholders is assessed to be a competitive strength in these companies and they attempt to take into account stakeholder opinions in setting objectives and priorities. The collaboration of these companies with stakeholders is based on the companies' own values and priorities and all the signals of stakeholders, and their functional environment is evaluated in relation to them (cf. Dentchev 2007). In order to identify important stakeholder groups and analyse the changes of functional environment forerunner companies have developed versatile means and methods. A particular feature of forerunner companies is that they have identified the primary stakeholders they have an impact on and are primarily responsible for. Especially when companies are close to end-users of products and services, communication with these and all stakeholders is assessed to be important as are the arising ideas to further development of company activities. Such approaches are gradually beginning to occur in other companies as well.

In conclusion, stakeholder analysis and related stakeholder management will remain as an important challenge to companies in the future.

4.3 Factors Guiding CSR in Companies

The factors guiding CSR in companies are both external and internal. Among the important external driving forces are legislation and stakeholder and customer expectations, as well as challenges arising from the external environment, especially globalisation. The primary internal factors driving CSR are the values of companies, the issues related to company image and the challenges related to the changing company environment. Again these are predicted to play a major role in the future.

An important factor influencing CSR is the need to become distinct from market competitors e.g. through better and more desirable products. Proactive enterprises differentiate themselves by engaging in the systematic development of CSR. Competition in markets determines much about strategic foci and ways of distinguishing a company from competitors, as well as how companies profile themselves, what kind of means and communications are used in profiling and, in the end, how this will guide and drive businesses. Survey results give indication of the connections between CSR, proactive future orientated planning and renewal of core businesses, and innovation activities and innovativeness. For example, new products and services play key roles especially in how companies distinguish themselves from competitors in markets and how they can benefit from customers. A detailed understanding of these connections will, however, require more in-depth examinations in the future.

The factors affecting CSR operational functions and procedures require long-term commitment of entire company activities. The responsibility in either developing competencies or operational procedures is common for the whole staff. The setting of clear long-term priorities for company functions supports the continuity and permanency as well as achievement of goals of responsibility. These issues also challenge top management and firms' business units to commit in the development of management competences for staff towards continuous change. According to experiences of forerunner companies, CSR development in the future will occur increasingly in collaboration with actors in the external environment as well as with other companies.

4.4 Impact of CSR on Competitiveness

One of the key objectives of the VTT study was to explore the existence of a relationship between CSR and competitiveness and especially whether the engagement in CSR contributes to competitiveness of companies. Figure 7.1 presents the assessments of survey respondents about the impacts of company activities on competitiveness. The respondents are given different alternative areas for assessing the impacts of CSR on competitiveness. In consequence, according to the respondents, when the question is about profiling company as a responsible enterprise or as a responsible employer CSR has improved competitiveness. Often CSR has improved competitiveness with respect to new or improved products and services, permanence of customer relations or attracting new employees. The improvement of competitiveness with respect to new or improved products may be interpreted as positive connection between innovation activities and CSR.

According to about one third of the respondents, CSR has had an impact on competitiveness by improving mental well being and motivation of employees, international market position and new or improved production processes. Moreover, according to one third of the respondents CSR has had an impact on competitiveness by improving the quality of activities and products. CSR has only had a minor impact on competitiveness with respect to reputation in financial markets, in the development of networks in the company branches or in the recognition of new areas of business.

The survey gives an opportunity to assess responses according to firm size. According to the responses of large companies when the question is about profiling of the company as a responsible enterprise, the reputation in investor and stock exchange markets, or cost savings and permanence of customer relations, competitiveness has improved. In other items there are insignificant statistical differences between respondents according to firm size. Yet the respondents of small and medium-sized companies often mention that CSR has had an impact on competitiveness in attracting new customers and supplier relationships, as well as in the recognition of weak signals in their industrial branch, in permanence of personnel and in mental well being and motivation of employees.

In conclusion, although the relationship between CSR and competitive advantage is complicated, this is assessed by the respondents of the VTT study to be positive.

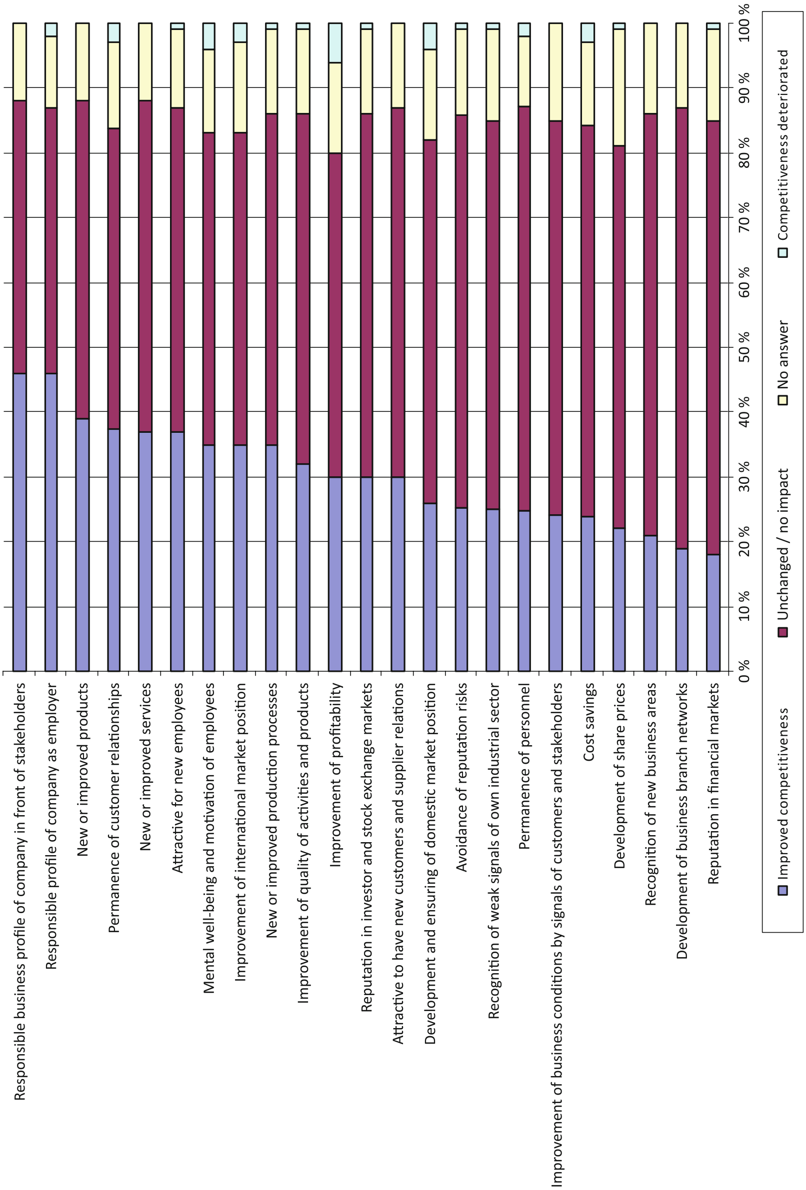

Fig. 7.1 Assessment of the respondents of impacts of responsible company activities on competitiveness

One of the survey questions asked directly whether CSR has improved competitiveness of companies and about two thirds of respondents indicated a positive answer, that is, CSR has improved their competitiveness. The impact of competitive advantage is related to company size; the bigger the company, the more respondents there were that indicated a positive relationship between CSR and competitiveness. The indication of any clear or straightforward cause–effect relationships between CSR and economic performance is however a challenging and demanding task as shown also in previous studies (see Sect. 2). An important aspect of these considerations is that benefits from responsible company activities accrue in the long run, and the observation of these benefits in short periods such as in a quarter of a year is hardly possible. From this perspective, performance arises from the quality of processes and realisation of values. In addition, performance is not only monetary in nature and hence responsibility needs to be assessed, not only through quantitative indicators, but also with qualitative indicators. Qualitative indicators may concern the realisation and implementation of firms' objectives and values or the quality of the operations, permanence of customer relationships and stakeholder cooperation. Besides quantitative and qualitative indicators it is important to produce versatile knowledge of the development trends affecting businesses.

4.5 Impacts Depend on the Definition of Competitiveness

The question of the connection of CSR to competitiveness is ultimately related to the question of how companies define competitiveness or competitive advantage. On the basis of the survey study, the definitions used of competitiveness by companies vary to some extent but analogies between terminologies used appear as well. According to respondents, the central elements of competitiveness are differentiation in the market, efficiency, profitability, customer satisfaction, high motivation of staff and the attractiveness and strength of products in the markets. The forerunner companies indicated that a linkage between CSR and competitiveness exists, but the time-span from the investments in responsibility to the impacts and returns to these investments is long and accordingly assessment of attribution of investments to impacts is complicated.

According to respondents, critical factors for company competitiveness are cost efficiency, competitive prices, business as well as business profit and growth of businesses. Profitable business creates a basis for competitiveness and for any of its supporting elements. The long-term perspective is an essential element also in developing the economic competitive advantage. Competitiveness was defined by respondents also on the basis of strong market position or 'market leadership'. According to respondents' interpretations also maintaining of the companies' market segments indicates competitiveness. Some of the respondents raised also success in international markets as a factor indicating competitiveness.

The ability of companies to produce services and technologies that are superior to and more attractive and desirable than competitors is also good criteria for assessing competitiveness. Likewise, continuous improvement and development of products and services as well as a capability of renewal are assessed as prerequisites for competitiveness. Moreover, the uniqueness and pre-eminence of products and services as compared to similar ones available in markets are assessed as important by respondents. Pre-eminence encompasses factors related to quality, pricing as well as factors related to responsibility of processes, and properties of products and services. Respondents assessed that the uniqueness of leading products is based on strong competencies and image. The ability to make things better than the others is one example of competitiveness. These different aspects give support also to arguments behind the Porter hypotheses discussed in Sect. 2 of this chapter.

According to the respondents' assessment, the important criteria in defining the competitiveness of companies are added value for customers, fulfilment of needs and expectations of customers, and the ability to foresee customer needs. The indicators used are versatile customer satisfaction surveys and corresponding questionnaires informing of the companies' image in front of customers and stakeholders (see also Sarkar 2008). A permanency of customer relationship is assessed as one relevant indicator of customer satisfaction, as are continuous improvement of customer satisfaction and customer services.

An important role in maintaining and renewing competitiveness, given in many responses of the survey study as well as in many interviews, was given to motivated and competent staff. The pre-eminence of products, services and all activities is assessed to depend primarily on the competence of personnel. It is the trust in competence of staff which is behind qualified and profitable business.

In conclusion, the interviews of forerunner companies and survey of 150 companies revealed the complexity of connections and cause–effect relationships between CSR and competitiveness.

5 Conclusions, Recommendations and Further Research

This chapter is about the potential link between CSR and competitiveness. A context for consideration consists of all dimensions of sustainable development, including the social and economic dimensions as well as the environmental dimension. The chapter is particularly about the mutual relationship between CSR and competitiveness. The study discussed in the chapter indicates that the relationship, especially the causal relationship between CSR and competitiveness, is complicated. Moreover, payback from the investment into the responsibility needs to be assessed in the long term. However, empirical evidence from the study does provide evidence of a positive relationship between CSR and competitiveness.

An important conclusion given by the evidence from the VTT study is that CSR *matters* for competitiveness. This evidence, in addition to corresponding evidence from previous research in the field (Margolis and Walsh 2001, Talvio and Välimaa 2004, see also Lankoski 2009), should encourage companies to develop CSR actively as an important factor having an impact on competitive advantage. Many aspects of the relationship between CSR and competitiveness vary in different companies and businesses because of varying sectoral characteristics, geography of markets and production, company size, role in business and value and supplier chains. Accordingly, the relationship between CSR and competitiveness is very company specific and the role and strategy with respect to CSR need to be examined in detail by each company separately.

When applied as an essential part of transparency and accountability in company policies, CSR will be desired and welcomed by shareholders and stakeholders. Consequently, the conclusion arising from the study is whether the data of the indicators related to CSR and competitiveness could be integrated and embedded more effectively into the management accounting system of enterprises. The VTT study indicated that particular and systematic opinion surveys of CSR among customers and stakeholders of companies are still rare and in many companies such data are collected as a part of customer and stakeholder surveys and events. If integrated, for example, in internet based management accounting systems, continuous data CSR can be provided 'on-line' for internal and external purposes.

The second conclusion of the VTT study relates to one of the results i.e. that from the three dimensions of sustainable development based on the sample, societal aspects were shown to be most important for companies. The question arising is whether current CSR indicators in environmental management accounting practices are sufficient from this perspective vis-à-vis the needs of internal improvement purposes for CSR and also vis-à-vis external communication needs with customers, shareholders and stakeholders.

The third conclusion relates to the need for further studies in the field. The VTT study considered brought essential additional understanding to causality between CSR and competitiveness. This issue with related complex causal relationships remains as an ongoing intellectual challenges for future research.

Appendix 7.1

Questionnaire for the Semi-Structured Internet Survey Study of 'Corporate Social Responsibility and Competitiveness – Current State and Future Prospects'

A Background

1. What is your organisational position?

   Given alternatives: • CEO • CSR director/manager • Director/manager of unit • Environmental director/-manager • Corporate communications-, social relationships director/-manager • Other, what?

B Concepts of CSR

2. What terms/concepts are used in your organisation or in your internal communication to describe responsibility?

   Given alternatives: • Social responsibility • Sustainable development • Corporate social responsibility • Responsible business • Societal responsibility • Sustainable business activity • Environmental responsibility • Pro-environmental business • Ethical business activity • Other, what?
3. What term is used in CSR reporting or in stakeholder communication to describe responsibility?

   Given alternatives: • Social responsibility • Sustainable development • Corporate social responsibility • Responsible business • Societal responsibility • Sustainable business activity • Environmental responsibility • Pro-environmental business • Ethical business activity • Other, what?
4. Confederation of Finnish industries (EK) defines the CSR as follows: Responsible business refers to uncompelled responsibility which supports firm's business and which is based on firm's values and objectives. Responsible business takes into consideration key requirements of stakeholders.
   Are you familiar with definition? Yes/No.
5. Does the term fit to describe the CSR in your organisation? Yes /No.
6. If 5 = no, why no____ (open).
7. When (year) have you started to develop corporate social responsibility systematically in your company? ____________.
8. What was the operational CSR model you started with? ______________(open).

C Factors Guiding and Motivating CSR in Companies

9. What external CSR requirements have OUTSTANDINGLY guided business activities in your company?
10. What are the focus development areas in the future? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)

    Given alternatives to 9–10: • Legislation • Operational environment-related factors • Stakeholder requirements • Requirements of private customers • Requirements of individual customers • Requirements of public customers • Requirements of other public actors • Requirements of company owners • Requirements of NGOs • Investor requirements • Financers´ requirements • Partners' requirements • Subcontractors' requirements • Suppliers' requirements • Requirements of local communities • Media • Competitors • Other, What?

11. What internal CSR requirements have OUTSTANDINGLY guided business activities in your company?
12. What are the focus development areas in the future? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)

    Given alternatives to 11–12: • Strong persons inside company • Top management • Company values • Requirements of main owners • Requirements of company principals • Requirements of CEO • Requirements of CSR directors • Requirements of personnel • Requirement of chancing business environment • Internationalisation of business • Internal needs of change • Good governance and accountability • Brand and PR issues • Success in markets • Risk management • Technology development • Image management • Continuity to environmental policy.
13. What CSR guidelines are used in your company when developing the CSR policy and operations?

    Given alternatives: YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI) • International declarations and guidelines of sustainable development • UN declaration of Human Rights • ILO pacts for fundamental rights in working life • OECD guidelines for multinational companies • Global Compact–initiative • Guidelines of industrial confederations • Criteria of financial organisations • GRI • Other reporting guidelines • Standard SA 8000 • Standard ISO 14001 • ISO quality standards • Quality system criteria • Accounting standards.

D Focus Areas of CSR

14. CSR encompasses economic, social and environmental dimensions. When thinking of ECONOMIC ASPECTS, which specific issues your company has paid attention to with respect to responsible company activities? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)
15. What are the focus development areas in the future? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)

Economic Aspects

Given alternatives to 14–15: • Competition regulations • Corruption regulation • Accounting standards • Accounting practice, insider rules • Ethical rules for marketing and advertising • Investments • Ethical investment • Ownership policy • Financial criteria • Public procurement criteria • Brand management • Customer relation management • Risk management • Other, what?

16. How important are economical issues when developing responsible company activities in your company? 5 = very important; 4 = rather important; 3 = not important, but not without any importance; 2 = not very important; 1 = not important at all.
17. With respect to SOCIAL ASPECTS, in which specific societal issues your company has paid attention to with respect to responsible company activities? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)
18. What are the focus development areas in the future? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)

Societal Aspects

Given alternatives to 16–17: • Hearing of stakeholders; • Welfare of citizens; • Management of employees' competences and intangible capital; • Equity /justice; • Occupational health and safety; • Promotion of working capacity; • Ageing; • Freedom of association and collective right to negotiate; • Human rights; • Child work; • Forced work; • Working conditions; • Neighbouring community; • Research institute and collaboration in education; • Product responsibility and safety; • Other, what?

19. How important are societal issues when developing responsible company activities in your company?

    Given alternatives: 5 = very important; 4 = rather important; 3 = not important, but not without any importance; 2 = not very important; 1 = not important at all.
20. With respect to ENVIRONMENTAL ASPECTS, in which specific environmental issues your company has paid attention to responsible company activities? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)
21. What are the focus development areas in the future? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)

    Given alternatives: • Environmental aspects; • Energy consumption; • Acquisition and use of raw materials; • Reduction of toxic substances; • Logging plans and practices of forests; • Responsible working methods of GM; • Control of eutrophication; • Development of environmental technology; • Responsible working methods of animal experiments; • Chemical safety; • Other, what?
22. How important are the following ecological aspects in the development of responsible activities in your company?

    Given alternatives: 5 = very important; 4 = rather important; 3 = not important, but not without any importance; 2 = not very important; 1 = not important at all.

E Stakeholders and Directing of Company Activities

23. What kind of practices your COMPANY uses the expectations and importance of the stakeholders? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)

    Given alternatives: • analysis of the current functional environment; • analysis of the functional environment of future; • dialogue with stakeholders; • foresight of stakeholder requirements; • target programs for stakeholder collaboration; • common working groups and projects with stakeholders; • assessment of the importance of stakeholder expectations; • prioritising of courses of action; • provision of stakeholder feedback; • customer events; • surveys of customer satisfaction; • attitude surveys/surveys of employees satisfaction; • development conversations of employees; • collaboration of supplier network; • collaboration with NGOs; • collaboration in legislation; • collaboration on the area of international principles and practices; • partner programs; • other, what?
24. How stakeholder views on responsible business have impacted the mode of operation of your company? YOU CAN SELECT AMONG MANY ALTERNATIVES (MULTI)

    Given alternatives: • change in decision-making practices of your company; • change in values of company; • setting the targets of responsibility; • a continuous improvement of responsible ways of action; • change in ways of action; • re-orientation of ways of action; • change in organisational culture; • new tasks and appointments; • re-organisation of supervisory responsibilities; • re-organisation of business units; • changes of budget of responsible business activity; • inclusion of responsible businesses in budgets of business activities.

F CSR and Competitiveness

25. How is *competitiveness* defined in your company? (OPEN ANSWER)
26. Has CSR improved competitiveness of your company? YES/NO; IF NO, WHY?
27. How the development of responsible business activity has changed ways of action and practices in your company during past three years? Assess the impact of following factors within the scale 3–1 where 3 = changed positively, 2 = stayed unchanged /no impact, 1 = changed negatively.

    Given alternatives: • development of good governance; • more balanced consideration of responsibility aspects in decision making; • strategic planning of activities; • consideration of responsibility aspects in setting strategic goals; • improved follow-up of realization of strategy; • development of management system; • selection of managers; • inclusion of responsibility issues in education of managers; • revision of values; • assessment of realization of values; • revision of ways of action policies; • enhancement of transparency; • assessment of importance of social responsibility; • development of network activities; • assessment of confidence capital; • assessment of company image; • assessment of societal effectiveness of activity; • development of risk management; • up-dating of introduction guidance; • up-dating of process descriptions/action handbook; • research and development; • own process development; • product development; • marketing/selling activities; • development of competences and skills; • recruitment policy; • revised personnel development practices; • development of internal communication; • development of external communication; • recognition of stakeholders; • assessment of stakeholders and the importance of their expectations; • reinforcement of stakeholder dialogue; • development of objectives and indicators emphasising responsibility; • development of reporting; • investment activities; • management of investment relationships; • selection of suppliers; • other, what?

28. How RESPONSIBLE COMPANY ACTIVITES have impacted on the competitiveness of your company? Assess the impact of following factors on the scale 3–1 where 3 = competitiveness has improved, 2 = stayed unchanged / no impact, 1 = competitiveness deteriorated.

    Given alternatives: • responsibility profile of company from the view of stakeholders; • reputation in investment and stock markets; • reputation in capital markets; • stock market development; • cost savings; • recognition of new business opportunities; • new or improved production methods; • new or improved products; • new or improved services; • improvement of profitability; • development/maintaining of position in domestic markets; • improvement of international market position; • new customers and supplier relations; • permanence of customers; • development of sectoral networks; • recognition of weak signals in own industrial sector; • profile as responsible employer; • acquisition of new employees; • permanence of personnel; • welfare and motivation of personnel; • avoidance of image/reputation risks; • improvement of quality of activities and outputs: • improvement of own operational preconditions by reflections to expectations of customers and stakeholders; • other, what?

29. If you have recognised in your activities new product, service or business opportunities, describe their relative importance compared to your current core businesses. (OPEN)

G Good Practices of Responsible Businesses

30. What factors have promoted the diffusion of responsible business ways of actions in your company. Describe shortly good practices of responsible activities in your company (OPEN).

Background Information

31. What is the main industrial sector of your company?

    Given alternatives: • Public administration; • Foodstuff industry; • Electricity-, gas- and water management; • Forest industry; • Building; • Chemical industry; • Transportation, storage and communication; • Metal and machinery industry; • Data management; • Electronic industry; • Other industry; • Research and development; • Other activities supporting businesses; • Other, what?; • No response.
32. Was the turnover of your business unit in last accounting period … less that 40 million Euros, over 40 million Euros… No response.
33. The number of employees in your business unit was…

    Given alternatives: Less than 10; 10–49; 50–99; 100–249; 250–499; 500 or more; No response.
34. Is your operational unit located …

    Given alternatives: In capital area (Helsinki, Espoo, Vantaa or Kauniainen); Elsewhere in South-Finland province; West-Finland province; East-Finland province; Oulu province; Lappland province; No response. Off-shore activities of company
35. How many percentage of the turnover of your company comes from off-shore activities? ___ %.

References

Banerjee SB (2008) Corporate social responsibility: The good, the bad and the ugly *Critical Sociology* 34.1 51–79

Crul M and Schnitzer H (1998) *Asia Eco-Best Preparatory Roundtable, Transferring European Cleaner Industrial Technology to Asia: The Role of Cleaner Technology Centres* Background Paper Lisboa, Portugal

Dentchev NA (2007) Corporate social performance: Business rationales, competitiveness threats and management challenges *Business Society* 46.1 104–116

Dentchev NA (2009) To what extent is business and society literature idealistic? *Business Society* 48.1 10–38

Eurosif (2008) *The European Social Investment Forum* [online] Available from Internet URL <http://www.eurosif.org/>

GRI (2008*) Sustainability Reporting Guidelines G3, 2008* [online] Available from Internet URL <http://www.globalreporting.org/Home>

Habisch A and Jonker J (2005) CSR – A subject with substance? *in* Habisch A, Jonker J, Wegner M and Schmidpeter R *Corporate Social Responsibility Across Europe* Berlin, Springer 1–9

Harris LC and Crane A (2002) The greening of organizational culture: Management views on the depth, degree and diffusion of change *Journal of Organizational Change Management* 15.3 214–234

Hongisto M, Loikkanen T, Kuisma J and Järvinen P (2001) *Case Studies on Environmentally Sound Innovations and Factors Affecting Them (Tapaustutkimuksia energia-alan* *ympäristömyötäisistä innovaatioista ja niihin vaikuttaneista tekijöistä)* IEE Reports No. 16/2001 Espoo, VTT [available only in Finnish]

Kuisma M (2004) *Differentiation or Convergence? Comparative Study on Environmental Management of Paper Industry Companies (Erilaistuminen vai samanlaistuminen? Vertaileva tutkimus paperiteollisuusyhtiöiden ympäristöjohtamisesta)* Helsinki, Helsinki School of Economics, Acta Universitatis Oeconomicae Helsingiensis A 232 [available only in Finnish]

Lankoski L (2009) Differential economic impacts of corporate responsibility issues *Business Society* 48.2 206–224

Loikkanen T, Hyytinen K and Koivusalo S (2007) *Corporate Social Responsibility an Competitiveness – Current State and Future Prospects* VTT Reports 2386/2007 Espoo, VTT [available only in Finnish]

Margolis JD and Walsh JP (2001) *People and Profits? The Search for a Link Between a Company's Social and Financial Performance* Hillsdale, Lawrence Erlbaum Associates

Maxwell J, Rothenberg S, Briscoe F and Marcus A (1997) Green schemes: Corporative environmental strategies and their implementation *California Management Review* 39.3 118–134

Montiel I (2008) Corporate social responsibility and corporate sustainability: Separate pasts, common futures *Organization Environment* 21.3 245–269

Nerth C (1998) Maintainability of first mover advantages when environmental regulations differ between countries *Academy of Management Review* 23.1 77–97

Porter M and van der Linde C (1996) Green and competitive: Ending the stalemate *in* Welford R and Starkey R *Business and the Environment* London, Earthscan Publications Ltd.

Roberts J (2003) The manufacture of corporate social responsibility: Constructing corporate sensibility *Organization* 10.2 249–265

Sarkar S (2008) Industrial social work to corporate social responsibility: A transformation of priority *Journal of Human Values* 14.1 31–48

Schmidheiny S, Zorraquin FJL and the World Business Council for Sustainable Development (1998) *Financing Change: The Financial Community, Eco-Efficiency, and Sustainable Development* Cambridge, The MIT Press

Talvio C and Välimaa M (2004) *Corporate Social Responsibility and Leadership (Yhteiskuntavastuu ja johtaminen)* Kauppakamarisarja, Johtamistaito Helsinki, Edita (available only in Finnish)

Chapter 8
Social Impact Measurement: Classification of Methods

Karen Maas and Kellie Liket

Abstract This paper analyses and categorises thirty contemporary social impact measurement methods. These methods have been developed in response to the changing needs for management information resulting from increased interest of corporations in socially responsible activities. The social impact measurement methods were found to differ on the following dimensions: *purpose*, *time frame*, *orientation*, *length of time frame*, *perspective* and *approach*. The main commonalities and differences between the methods are analysed and the characteristics of the methods are defined. The classification system developed in this chapter allows managers to navigate their way through the landscape of social impact methods. Moreover, the classification clearly illustrates the need for social impact methods that truly measure impact, take an output orientation and concentrate on longer-term effects. This chapter also discusses the lack of consensus in defining social impact. The paper concludes with a brief discussion on theoretical and practical implications.

Keywords Social impact • Social impact measurement methods • Managerial decision making • Impact value chain • Performance measurement

1 Introduction

In the last decade responsible corporate behaviour has been a major topic of both academic and public discourse. Consequently, tools have been developed for both the managing and reporting of the wide range of corporate responsibility activities.

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This chapter outlines a classification system for contemporary measurement methods developed to measure social impact. The term *social impact* is used for the impact of a corporation on society on the economic, environmental and social dimension. While environmental accounting methods have been embraced by academics and a wide range of corporations (Burritt and Saka 2006, Schaltegger et al. 2002), the landscape of social impact methods has yet to be categorised. The purpose of the categorisation performed in this paper is twofold. First, it allows for the analysis of status quo of the social impact methods for corporate social responsibility (CSR) and second, it aids the CSR manager in the navigation through the wide range of existing tools.

Analogous to financial accounting methods, environmental and social accounting methods aim to measure the impact of corporate activities on society. Such social and environmental impacts are often not expressed by the market, do not have a market value, and are therefore often ignored by corporations (Elkington 1999, Lamberton 2005, Schaltegger and Burritt 2000). However, accounting methods provide crucial information for managerial decision making (accounting for decision-making) and for internal and external reporting (accounting for control) (Zimmerman 2009). Whereas environmental accounting methods are relatively widespread, as shown by their frequent occurrence in annual reports, CSR activities often extend to more numerous dimensions than the environmental one, with impact on both the economy and society. The lack of consensus on the definition of social impact and the best way to measure it hampers both the academic debate on social impact, as well as the use of social impact methods (Maas and Boons 2010). This chapter is a first attempt at increasing consensus by analysing social impact and categorising contemporary social impact methods.

2 From a Single Towards a Multiple Bottom Line

Although CSR is widely used, numerous terms refer to the social behaviour of corporations, such as community involvement, corporate responsiveness, corporate citizenship, corporate social performance and many others (de Bakker et al. 2005, Maas and Bouma 2005, Matten et al. 2003). Nevertheless, all terms refer to actions that have been defined by McWilliams and Siegel (2001:117) as ‘an action that appears to further some social good, beyond the interest of the corporation and that which is required by law’. It is important to recognise that these actions are not specific to the private sector (Clark et al. 2004) as both governments and nonprofit organisations undertake actions to provide value for society. The demands for more tangible accountability in these sectors have also increased their attention on the need for social impact methods (London 2009).

Traditionally, it was believed that value is either economic created by for-profit organisations or social created by nonprofit or nongovernmental organisations (Ben-Ner and Hoomissen 1992, Weisbrod 1988). In alignment with this belief it is not surprising to find that social impacts are often not explicitly included in valuation studies or are ignored. Moreover, existing research puts most emphasis on the business case or the payback results of social initiatives for corporations, instead of an emphasis on the impact of social initiatives (Aguilera et al. 2007, Fry et al. 1982, Juholin 2004, Margolis and Walsh 2003). However, Emerson (2003) finds that the number of mainstream corporate CEOs discussing the social and environmental impacts of their corporations as a strategy for increasing the total value of their corporations has increased.

Elkington (1999) predicts the evolution of win-win thinking in business providing support for a more active attitude toward CSR. A similar integrated approach to CSR is the triple bottom line (TBL) concept. The TBL concept focuses on value creation[1] across the three dimensions of sustainability: economic, social and environmental. Although this concept has been widely used, the interpretation of value creation differs among users; some interpret TBL as a zero-sum game while others view it as an optimisation game of blended value (Emerson 2003). The idea behind the blended value is that all corporations, whether for-profit or not, create value that consist of economic, social and environmental value components and this value is itself nondivisible and, therefore, a blend of these three dimensions (Ann et al. 1999, Elkington et al. 2006). Consequently, the challenge for any organisation, nonprofit, nongovernmental, or for-profit, is to optimise impacts on several dimensions instead of maximising impacts against a single dimension.

The movement toward a more integrated approach toward value creation by corporations has shifted from a more defensive to a more encompassing approach. Under numerous external pressures, originating from stakeholders such as consumers, rating agencies and governments, corporations gradually changed their attitudes toward CSR (see Fig. 8.1). While the 1970s were characterised by defensive attitudes, in the 1980s corporations started to work with environmental managers. It was not until the 1990s that the attention for CSR in process and product design grew extending the involvement to marketing managers. In the

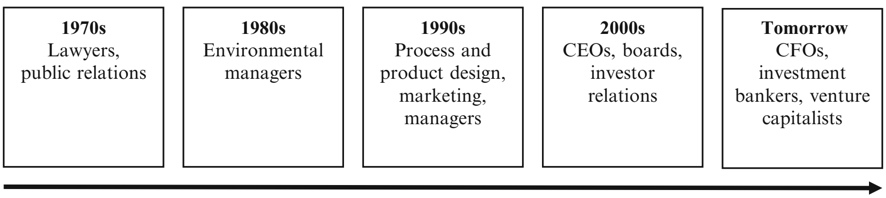

Fig. 8.1 Internal involvement in the corporate goals (based on Elkington et al. 2006)

[1]The primary pursuit of corporations is to create value (Conner 1991). Value refers to the value created minus cost incurred. This implies that value can be either positive or negative. Value creation is a central concept in management and organisational literature (Lepak et al. 2007; Verwaal et al. 2009). However, what actually constitutes value is often left unaddressed in these theories (Maas and Boons 2010).

2000s CSR entered the board rooms and required the involvement of CEOs. Elkington et al. (2006) predict that in the future involvement will extend to CFOs, investment bankers and venture capitalists.

It is important to note that the involvement of a wide variety of constituents within the corporation does not guarantee socially responsible behaviour. The debate on the intentions of corporations in their engagement in CSR can be categorised in three perspectives. Whereas the first perspective faithfully pursues Friedman's argument that the business of business is business (Friedman 1970, Matten et al. 2003), the opposite perspective points to the good intentions of corporate leaders or CSR managers (e.g. Husted and Salazar 2006, Porter and Kramer 2006). The third perspective takes a middle-of-the-road approach in that it attempts to integrate good intentions with financial gains by pointing out the indirect benefits of CSR through employee satisfaction or corporate reputation (Margolish and Walsh 2003).

Regardless of the perspective taken, it is reasonable to assume that corporations have an interest in social impact measurement for reporting and decision-making purposes. In the latter case, social impact measurement allows for a first step in the process toward optimising value on multiple dimensions. For corporations and their investors, relatively standardised measurement and reporting guidelines have been developed that provide clear insight into the financial efficiency of a corporation. Measuring the impact upon the society, however, remains a much greater challenge.

3 Definitions of Social Impact

The lack of consensus on the definition of social impact causes confusion and hampers the ability to study the phenomenon. Variations are found between the various academic fields such as business and society studies, management accounting and strategic management. An overview of a number of definitions can be found in Table 8.1 (e.g. Burdge and Vanclay 1996, Latané 1981). Main differences are found in the usage of words such as *impact*, *output*, *effect* and *outcome*. Moreover, the term *social impact* is often replaced by terms such as *social value creation* (Emerson et al. 2000) and *social return* (Clark et al. 2004).

Here, the definition of social impact as developed by Clark et al. (2004) is used: 'by impact we mean the portion of the total outcome that happened as a result of the activity of an organisation, above and beyond what would have happened anyway.'

This definition is based on the so-called Impact Value Chain (see Fig. 8.2) and is used to differentiate outputs from outcomes and impacts. By including 'what would have happened anyway' in the definition, the use of a benchmark or counterfactual is inferred. Differentiation between elements of the social value chain illustrates the conceptualisation of the idea that impacts are different from outputs. While outputs and outcomes are related to the provider of the product, activity, or service, impacts are associated with the user (Kolodinsky et al. 2006). It is important to note that

Table 8.1 Definitions of social impact and related terms

Term	Definition
Social impact (Burdge and Vanclay 1996)	By social impacts we mean the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organise to meet their needs and generally act as a member of society
Social impact (Latané 1981)	By social impact, we mean any of the great variety of changes in physiological states and subjective feelings, motives and emotions, cognitions and beliefs, values and behaviour that occur in an individual, human, or animal, as a result of the real, implied, or imagined presence or actions of other individuals
Impact (Clark et al. 2004)	By impact we mean the portion of the total outcome that happened as a result of the activity of the venture, above and beyond what would have happened anyway
Social value (Emerson et al. 2000)	Social value is created when resources, inputs, processes, or policies are combined to generate improvements in the lives of individuals or society as a whole
Social impact (Freudenburg 1986)	Social impact refers to impacts (or effects, or consequences) that are likely to be experienced by an equally broad range of social groups as a result of some course of action
Social impact (Gentile 2000)	Social impacts are the wider societal concerns that reflect and respect the complex interdependency between business practice and society
Social impact (IAIA[a] by Wikipedia 2009)	Social impacts are intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions

[a]International Association for Impact Assessment, www.iaia.org

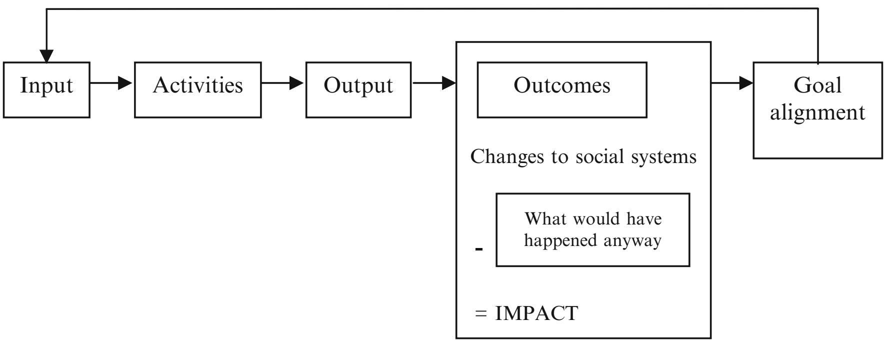

Fig. 8.2 Impact value chain (adapted from Clark et al. 2004)

impacts include intended as well as unintended effects, negative as well as positive effects and both long-term and short-term effects (Wainwright 2002). Ideally, evaluation of the impact is used to inform goal alignment.

4 Developments in Performance Measurement

From an economic perspective, the purpose of economic behaviour is believed to be the maximisation of wealth or profit attained by the management of scarce resources in the best possible manner. Therefore, emphasis is placed on the need for managers to seek efficient outcomes (Burritt and Saka 2006). Efficiency measures the relation between outputs and inputs to a process. The higher the output for a given input, or the lower the input for a given output, the more efficient the activity, product, or corporation is. The general understanding of both investment and return is founded upon a traditional separation of social value and economic value. However, the pursuit of a blended value for investments and returns does not separate social and financial impacts but is composed of both (Emerson 2003).

Conventional performance measurement is often based on the goal-attainment approach and does not usually consider social or environmental questions. The assumption that underlies the goal-attainment approach is that the goals of an organisation are identifiable and unambiguous (Forbes 1998). An organisation's effectiveness is represented by the attainment, or progress toward, organisational goals. Attaining organisational goals such as increasing production, increasing profit, or reducing costs can be researched by using conventional performance measurement methods. Incorporating impact upon society along various dimensions of performance measurement – economic, environmental, social – complicates the ability to identify, measure and value such impacts. While generally accepted principles of financial accounting are established to measure and report on the economic impact at an organisational level, comparable standards for measuring the impact upon society have yet to be developed (Maas and Bouma 2005). Consequently, current practice in performance measurement tends to focus on measuring only a part of the total impact that organisations have on society.

In order to develop this integrated blended value perspective accounting methods would have to integrate all three dimensions. Eccles (1991:131) envisaged the start of a revolution in performance measurement and predicted that 'within the next five years, every corporation will have to redesign how it measures its business performance'. Corporations traditionally have relied almost exclusively on financial measures of performance (Ittner and Larcker 1998). New strategies and competitive realities demand new measurement systems for integrating social dimensions of corporate performance.

New information systems and processes capable of measuring the creation of value in relation to the social dimensions of corporate performance are needed. A step forward is to look beyond traditional financial, monetary and quantifiable measures of impacts of activities and explore and incorporate methodologies borrowed from other disciplines such as sociology. Corporations judge their success on the basis of the tasks completed and milestones achieved – the amount of money invested, quantity of products distributed and so on – rather than on how well their activities translate into changes on the ground (London 2009). Impacts can be measured at different levels: individual, corporation and societal. The integration of social impact into the processes of decision making, planning and problem-solving requires an innovative and interdisciplinary approach. Behind the scenes, scientists, practitioners and consultants develop improved (multidisciplinary) methodologies for assessing impacts against the double bottom line, the triple bottom line, or other concepts linked to multidimensional value creation. An overview of methods is provided in the next section.

5 Social Impact Measurement

5.1 Absence of a Categorisation

Despite the practical and theoretical importance of categorising social impact measurement methods, a system to do so has not yet been developed. Multiple reasons could have contributed to this absence. For one, social impacts are often difficult to measure and quantify. The qualitative nature of social impact makes it hard to attach an objective value to the impact and to sum the various qualitative expressions of impact. Second, corporations can have a positive or negative impact upon the society along three dimensions: environmental, economic and social. Similarly, this can cause problems with adding the various impact dimensions. Third, social impact includes short-term as well as long-term effects on society. Moreover, many components can contribute to economic, environmental and social impact. Consequently it is often hard to link activities to impact because of difficulties with attribution and causality questions. Currently, no widely accepted scientific approach to attribution and causality questions in impact measurement exists. Finally, the greatest difficulty might be the challenges around finding a consensus on the definition of social impact. Whereas some researchers refer to social impact when it includes positive, negative, intended and unintended effects, others refer to the intended positive effects (Boyne 2002, Ebrahim 2005). Moreover, consensus is absent on the use of a counterfactual or benchmark and whether or not social impact by definition requires data collection in a participatory manner.

5.2 An Overview of Methods

From the 1990s, many methods have been developed to measure social impact. Literature review, internet search and expert information resulted in a list of thirty quantitative social impact measurement methods[2] (see Table 8.2) (e.g. Clark et al. 2004,

[2]It must be emphasized that the focus here is on quantitative methods that are able to measure impact on society. In addition to these methods many qualitative methods exist, e.g. story telling, content analysis, and word counting. Guidelines, principles and standards such as GRI, AA1000, SA8000, ISO 26000, are not included in this list.

Table 8.2 Overview of social impact measurement methods

Social Impact measurement methods
1. Acumen scorecard
2. Atkinsson compass assessment for investors (ACAFI)
3. Balanced scorecard (BSc)
4. Best available charitable option (BACO)
5. BoP impact assessment framework
6. Center for high impact philanthropy cost per impact
7. Charity assessment method of performance (CHAMP)
8. Foundation investment bubble chart
9. Hewlett foundation expected return
10. Local economic multiplier (LEM)
11. Measuring impact framework (MIF)
12. Millennium development goal scan (MDG-scan)
13. Measuring impacts toolkit
14. Ongoing assessment of social impacts (OASIS)
15. Participatory impact assessment
16. Poverty social impact assessment (PSIA)
17. Public value scorecard (PVSc)
18. Robin hood foundation benefit–cost ratio
19. Social compatibility analysis (SCA)
20. Social costs–benefit analysis (SCBA)
21. Social cost-effectiveness analysis (SCEA)
22. Social e-valuator
23. Social footprint
24. Social impact assessment (SIA)
25. Social return assessment (SRA)
26. Social return on investment (SROI)
27. Socioeconomic assessment toolbox (SEAT)
28. Stakeholder value added (SVA)
29. Toolbox for analysing sustainable ventures in developing countries
30. Wellventure monitor

Epstein 2008, Schaltegger et al. 2002). Quantitative methods are needed for corporations to make intangible results more tangible and to use social impact measurement for decision making and control issues. This list is not intended to be exhaustive but provides an overview of social impact measurement methods.

Several methods have been developed by or for nonprofit or governmental corporations. Examples (see Table 8.2) are Social Return on Investment (SROI), Ongoing Assessment of Social Impacts (OASIS), Social Costs–Benefit Analysis (SCBA) and Local Economic Multiplier (LEM). Other methods are mainly developed for and used by for-profit corporations. Examples are Social Return Assessment (SRA), Atkinsson Compass Assessment for Investors (ACAFI), TBL, Measuring Impact Framework (MIF) and Best Available Charitable Option (BACO). Although a method might initially have been developed for a certain kind of organisation, the method could be used and adapted by other kinds of organisations. The use of SROI is a good example of this phenomenon. This method was initially developed for nonprofit organisation and is currently increasingly used by for-profit corporations. Next to these quantitative impact measurement methods several corporations, nongovernment organisations and associations developed guidelines or frameworks, often based on one or more existing methods, on how to measure social impact. A few examples are the 'guidance document for the oil and gas industry' (IPIECA 2008) and two guidelines developed by Shell (Shell 2008a, b).

5.3 Characteristics of Methods

There is a need for a wide range of methods tailored to the requirements of different types of corporations, depending on their activities, objectives and the aspects of impacts they want to measure. There is no single tool or method that can capture the whole range of impacts or that can be applied by all corporations. The multitude of existing social impact measurement methods is confusing for managers when selecting a method or academics when analysing progress in social impact measurement. Existing measurement methods do not show a common understanding of what to measure, why or for whom to measure, or how to measure.

Borrowing insights from environmental accounting for a system to categorise measurement methods, four suggestions for categorisation can be found:

- Schaltegger et al. (2000) develop a framework for the instruments of environmental accounting;
- Loew et al. (2001) and Loew (2003) systematise cost concepts by combining environmental impact and environmental costs;
- Clark et al. (2004) categorise measurement methods into three: process methods, impact methods and monetarisation methods; and
- The US-EPA (1995) publishes a study with key concepts and terms related to environmental accounting.

Specifications of these systems might be useful to characterise social impact methods. From careful analysis it is found that the framework as developed by Schaltegger et al. (2000) and the categorisation from Clark et al. (2004) are useful to the categorisation of social impact methods. The other frameworks focus more on output and cost relations (Loew et al. 2001), or on concepts and terms (US-EPA 1995) instead of classification of methods. Schaltegger et al. (2000) distinguish five dimensions of environmental accounting methods:

1. Information type: monetary versus physical
2. Scope: internal versus external
3. Length of time frame: short-term focus versus long-term focus
4. Time frame: past-orientated versus future-orientated
5. Routineness of information: routinely generated information versus ad hoc information

From this categorisation the time frame and length of time frame dimensions are relevant for the categorisation of social impact methods. From Clark et al. (2004) the categorisation toward the approach to methods is relevant for the categorisation

Table 8.3 Characteristics of social impact measurement methods

Characteristics	Types
Purposes	Screening Monitoring Reporting Evaluation
Time frame	Prospective Ongoing Retrospective
Orientation	Input Output
Length of time frame	Short term Long term
Perspective	Micro (individual) Meso (corporation) Macro (society)
Approach	Process methods Impact methods Monetarisation

of social impact methods. As a result, it is found that methods differ on the following dimensions: purpose, time frame, orientation, length of time frame, perspective and approach. Table 8.3 provides an overview of method characteristics relevant for method selection.

5.3.1 Purpose

Measurement methods can be developed for different purposes depending on what it is intended to measure. Methods that are particularly suited for (a) screening, (b) monitoring, (c) reporting and (d) evaluation were identified. Methods suited for screening facilitate evaluation of investment opportunities and of their performance with respect to investors' specific social and financial objectives. Methods suited for monitoring assist management with ongoing operational decision making and provide data for investor oversight. It may also help entrepreneurs to identify business model modifications or market opportunities. Methods for reporting are particularly useful to report to external stakeholders, such as potential investors, the public, or other entities, which require or request performance reports on a regular basis. Methods for evaluation may be used for retrospective, ex-post impact assessment of achievements for academic purposes but also for organisational learning.

5.3.2 Time Frame

Methods may use a different time frame for the assessment. Some methods can be applied prospectively to assess impacts which can, for example, be expected from planned reforms and programs. Those methods have the ability to open space for different options, support the design of mitigation measures and modifications and assist decision-makers in choosing the options which best fit (IPC 2008). Methods can also be developed with a focus on ongoing or retrospective purposes. Methods focusing on the ongoing events are useful for testing assumptions along the way. Retrospective methods are useful for evaluation of past activities.

5.3.3 Orientation

Methods can have either an orientation on inputs or an orientation on outputs. Input-orientated methods are useful to assess differences in input, for example, expenditure saved by increased employee satisfaction, as a result of a social activity. Output-orientated methods on the other hand are useful to assess differences in output as a result of a social activity, for example, a better reputation.

5.3.4 Length of Time Frame

Methods can have a length of time frame focusing on long term or short term. In more traditional measurement methods, the focus is normally on the short term. However, for social impact measurement, both a short-term and long-term focus can be needed. Impacts often do not occur in the short term; it can take a long time before social impacts occur. An example is the global warming effects resulting from greenhouse gasses.

5.3.5 Perspective

Measurement methods can use a different perspective. Measurement methods originating from, for example, business measurement, social science evaluation, policy or program evaluation, all use different perspectives. An initial inventory shows that social impact measurement from a business or micro perspective does include, for example, different indicators than social impact measurement from a macro socioeconomic perspective (Maas and Bouma 2005). Depending on the perspective used, different indicators will be needed and therefore different impacts will be measured. Consequently, the perspective used is decisive for the results of the measurement.

5.3.6 Approach

Methods can have different approaches to measuring social impact. In the literature, three broad categories of methods are defined: process, impact and monetarisation (Clark et al. 2004). Process methods monitor the efficiency and cost-effectiveness of ongoing operational processes. As such, they do not provide an absolute measure of social returns. However, outputs can be evaluated by the extent to which they correlate with or cause desired social outcomes. Impact methods measure operational outputs and their impact, i.e. the incremental outcome beyond and above what would have happened if the organisation did not exist. Impact can be measured in several ways. There are methods that measure impact by linking Corporate Social Performance and Corporate Financial Performance (Dentchev 2004, McWilliams and Siegel 2000, Margolis et al. 2003). Another example of impact methods is the so-called "3P approach" where the economic dimension (Profit), social dimension (People) and environmental dimension (Planet) are all measured in their own unit (Elkington 1999, GRI 2006, Labuschagne et al. 2005). Next to this, monetarisation methods quantify social and environmental indicators and translate those indicators into a monetary value to be comparable with traditional financial data (Lamberton 2005, Pearce et al. 2006). A comprehensive overview of several monetarisation methods can be found in the environmental economic literature (Pearce et al. 1994, 2006).

5.4 Classification of Methods

All methods are classified based on the characteristics as specified in the previous section. The classification is based on descriptions of the individual tools[3] provided by the developers, researchers or obtained from the internet. The results are shown in Table 8.4.

The tables show the characteristics of the different methods. By doing this it can be easily seen for which purpose the different methods can be used (screening, monitoring, reporting and evaluation). Next the table shows which time frame, orientation, length of time frame and perspective that the methods adopt. Finally, the approach used by the methods can be observed.

5.4.1 Purpose

Almost all of the thirty methods can be used for multiple purposes. More than half of the methods (17/30) fulfill screening purposes, facilitating an evaluation of investment opportunities or performance relative to the investor's social and financial objectives. A similar number of methods (18/30) can be used to monitor social impact. In almost half of the cases (12/30) the two purposes of monitoring and screening overlap. A much more dominant purpose of the social impact measurement methods is reporting (24/30), which signals that measuring social impact is regularly motivated by the need to report to external stakeholders. Finally, the most dominant purpose (25/30) of social impact methods is evaluation.

[3] In Appendix 8.1, a short description of social impact measurement tools is provided.

Table 8.4 Classification of social impact measurement tools

Characteristics	Types	1. Acumen scorecard	2. ACAFI	3. Balanced scorecard	4. BACO	5. BoP impact assessment framework	6. Center for High Impact Philanthropy Cost per Impact	7. CHAMP	8. Foundation investment bubble chart	9. Hewlett foundation expected return	10. Local economic multiplies	11. Measuring impact framework	12. MDG-scan	13.Measuring impacts toolkit	14. OASIS	15. Participatory impact assessment
Purposes	Screening	X	–	X	X	X	X	–	–	X	X	X	–	–	–	X
	Monitoring	X	X	X	X	X	X	–	–	–	–	X	–	–	X	X
	Reporting	X	X	X	X	X	X	X	X	–	–	X	X	–	X	X
	Evaluation	–	–	X	–	X	X	X	X	–	X	X	X	X	X	X
Time frame	Prospective	X	X	X	X	X	X	–	–	X	X	X	–	–	–	X
	Ongoing	X	X	X	X	X	X	–	X	–	–	X	–	–	X	X
	Retrospective	–	–	X	X	X	–	X	X	–	X	X	X	X	X	X
Orientation	Input	X	X	–	X	X	X	X	–	–	X	X	–	X	X	X
	Output	–	–	X	–	–	–	–	X	X	–	–	X	–	X	–
Length of time frame	Short term	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Long term	X	X	–	–	–	X	–	–	–	–	X	–	–	–	X
Perspective	Micro (individual)	–	X	–	–	X	X	X	X	X	X	–	–	X	X	X
	Meso (corporation)	X	X	X	X	X	–	–	–	–	X	X	–	X	–	–
	Macro (society)	–	–	X	X	X	X	X	X	X	–	X	X	X	X	X
Approach	Process methods	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Impact methods	–	–	O	–	X	–		–	–	–	X	O	–	X	X
	Monetisation	–	–	–	X	–	–	–	–	–	X	–	–	X	X	–

(continued)

Table 8.4 (continued)

Characteristics	Types	16. PSIA	17. Public value scorecard	18. Robin Hood Foundation benefit–cost ratio	19. SCA	20. SCBA	21. SCEA	22. Social e-valuator	23. Social footprint	24. SIA	25. Social return assessment	26. SROI	27. SEAT	28. SVA	29. Toolbox for analysing sustainable ventures	30. Wellventrue monitor
Purposes	Screening	X	–	X	X	X	–	–	X	X	X	–	–	–	X	–
	Monitoring	–	X	–	X	–	–	X	X	X	X	X	X	–	X	–
	Reporting	X	X	X	–	X	X	X	X	X	X	X	X	–	X	X
	Evaluation	X	–	X	X	X	X	X	X	X	X	X	X	X	X	X
Time Frame	Prospective	–	X	X	X	X	–	–	X	X	X	–	–	–	X	–
	Ongoing	–	X	X	X	X	–	X	X	X	X	X	X	–	–	–
	Retrospective	X	–	X	–	X	X	X	X	X	X	X	X	X	X	X
Orientation	Input	X	X	–	X	X	X	X	–	X	X	X	X	–	X	–
	Output	–	–	X	–	–	–	–	X	–	–	–	–	X	–	X
Length of Time Frame	Short term	X	X	X	X	X	X	X	X	X	X	X	X	–	X	–
	Long term	X	–	X	–	X	X	–	X	–	–	–	–	–	X	X
Perspective	Micro (Individual)	X	–	–	–	–	–	X	X	–	X	X	–	–	X	X
	Meso (corporation)	–	X	–	X	–	–	–	X	–	X	–	X	X	X	X
	Macro (society)	X	X	X	X	X	X	O	X	X	X	O	X		X	X
Approach	Process methods	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Impact methods	X	–	X	–	X	–	O	–	X	–	O	–	–	–	–
	Monetization	–	–	X	–	X	X	X	–	–	X	X	–	X	O	–

Characteristic of tool; X: yes, O: partially, –: no

The Measuring Impacts Toolkit (MIT) and the Stakeholder Value Added (SVA) are solely evaluation tools. However, five of the methods allow for both evaluation and reporting; Charity Assessment Method of Performance (CHAMP), Foundation Investment Bubble, Millennium Development Goal scan (MDG-scan), Social Cost-Effectiveness Analysis (SCEA) and Wellventure Monitor. The Local Economic Multiplier allows for both evaluation and screening. Nine out of the thirty (9/30) measurement methods (in Table 8.2 numbers 3, 5, 6, 11, 15, 23, 24, 25 and 29) can be used for all purposes.

5.4.2 Time Frame

The social impact measurement methods most often allow for the use of different time frames. In nine out of thirty methods (9/30) only a retrospective time frame can be taken. As expected, in all cases these methods have the purpose of evaluation, sometimes in combination with other purposes. Only Hewlett Foundation Expected Return takes a solely prospective time frame, as its purpose is screening of investment. The measurement methods that can be used for all purposes also allow for the use of all time frames except for Toolbox for Analysing Sustainable Ventures and Centre for High Impact Philanthropy Cost per Impact.

5.4.3 Orientation

Only one method Ongoing Assessment of Social Impacts (OASIS) has an orientation on both inputs and outputs of social activity. Most methods look at the differences in inputs that result from a social activity (21/30). Only eight methods look at the differences in output as a result of the social activity. Those methods with an output orientation always have a retrospective time frame.

5.4.4 Length of Time Frame

Less than half of the methods (12/30) take a long-term frame of time. All methods except for SVA, which specifies no length of time frame, and the Wellventure Monitor, which takes a long-term time frame, also measure social impact for the short term.

5.4.5 Perspective

Six methods (6/30) analyse social impact from micro-, meso- and macroperspectives. These are often methods that also allow for all time frames and purposes. Eleven methods (11/30) take a microperspective. Ten methods analyse the mesoperspective and 18 take the macroperspective. Two methods partially use the macroperspective (making the total 20/30 for macro).

5.4.6 Approach

Only eight out of the thirty (8/30) methods truly measure impact, with four methods partially measuring impact making the total 12/30. A relatively large number of methods, eleven out of thirty (11/30), allow for the monetarisation of the social impact measured, with one method partially doing so making the total 12/30.

The classification of methods shows that despite the development of numerous social impact methods, only eight of the thirty methods actually measure social impact, and four methods are capable of partially[4] measuring social impact. Most of the methods have an orientation toward inputs rather than outputs. While most methods are useful for reporting, hardly any methods are specifically designed for reporting purposes. With the exception of three methods, all are useful for evaluation purposes. Only one method, the Hewlett Foundation Expected Return, is limited to a purely prospective time frame and is therefore only useful for screening purposes. All methods take a process approach. Moreover, 11 methods are developed to transfer all effects into monetary units. The methods that truly aim at measuring impact all have a macro societal perspective. All methods are designed to include short-term effects, while only 12 methods are capable of including long-term effects.

6 Conclusions

The wide range of social impact measurement methods makes it hard for managers to select a suitable method for the measurement of the social impact of their social activities. In part the difficulty stems from the lack of consensus on the definition of social impact. However, the challenges mostly stem from the absence of a categorisation system for these methods. In this chapter such a classification system has been developed, providing managers with a framework that allows for the selection of the most suitable method depending on their needs.

In the literature several frameworks, classification schemes and systems of concepts exist. However, these concentrate on environmental accounting and environmental management accounting. The classification system that has been developed in this paper is a combination of the framework that is dominant in environmental accounting by Schaltegger et al. (2000) and a framework by Clark et al. (2004) that specifies different approaches used by impact measurement methods. A number of additional characteristics are included as they are specifically relevant to social impact methods, such as purpose, perspective and orientation.

[4]When a method, for example, only takes intended impacts into account or makes use of predetermined indicators for impact measurement it is categorized as 'partially'.

The classification system includes six characteristics: *purposes* – methods can be used for screening, monitoring, reporting and evaluation; *time frame* – can be either prospective, ongoing, or retrospective; *orientation* – methods can be input or output-orientated; *length of time frame* – methods can address a short-term or a long-term time frame; *perspective* – methods can use an individual, organisational, or community or societal perspective; and, *approach* – methods can use different approaches to measure impact, i.e. process, impact, monetarisation.

While all methods identified have been specifically developed to measure social impact, this research shows that only eight of the thirty methods actually do so. These methods all adopt a macrosocietal perspective. In view of the rising interest in social impact measurement the development of this classification will provide managers with a way forward in seeking to adopt social impact measurement. The classification clarifies the concept and applicability of social impact tools.

This research is limited as the analysis of the methods is based on conceptual research, combined with interviews with experts and users of the methods. However, future research could take this analysis a step further by conducting comparative analyses of the methods in an applied research setting. Measuring the practicality, as well as the reliability and validity, of the methods could be undertaken by using a number of methods to capture the social impact of a single social activity. This could be extended by selecting a number of similar activities and also comparing the results across them. Such analyses would provide a rigorous way to compare the features, possibilities and limitations of the methods. Moreover, it might be helpful to develop a guideline for managers with examples from practice to aid to the process of choosing a social impact measurement method.

Appendix 8.1: Description of Social Impact Measurement Methods

1 Acumen Scorecard

Adapted from a description in Clark et al. 2004.

Developed in 2001 by: Acumen Fund in association with McKinsey, a nonprofit enterprise that invests in and grants to both nonprofit and for-profit ventures in its portfolio.

> The system was developed to assist both for profit businesses, and not-for-profit corporations focus on actions that deliver both immediate results and improve an corporations long-term competitive positioning in changing and dynamic marketplaces.
>
> The system assesses the social ventures investments in Acumen's portfolio of for-profit and non-profit corporations. It entails tracking progress on short- and long-term outcomes, which is assessed in terms of outcome milestones and benchmarks.

http://www.acumensms.com/

2 Atkisson Compass Assessment for Investors (ACAFI)

Adapted from a description in Clark et al. 2004.

This system is developed by AtKisson Inc.in 2000.

> This method builds on AtKisson's Compass Index of Sustainability, a tool for assessment of the sustainability of communities. The framework for investors is designed to integrate with the reporting guidelines of major CSR standards, particularly the Global Reporting Initiative (GRI) and the Dow Jones Sustainability Index (DJSI), as a venture matures. The method incorporates a structure with five key areas: N = nature (environmental benefits and impacts) S = society (community impacts and involvement) E = economy (financial health and economic influence), and W = well-being (effect on individual quality of life), and a fifth element, + = Synergy (links between the other four areas and networking), and includes a point-scale rating system on each of the five areas. Each area has several indicators each of which has specific criteria. The method has been peer reviewed by corporate executives, economic academicians, and investment professionals.

http://atkisson.com/wwd_tools.php

3 Balanced Scorecard (BSc)

Adapted from a description in Clark et al. 2004.

The Balanced Score Card is developed by Robert Kaplan and David Norton in 1992.

> The Balanced Scorecard proposes that corporations measure operational performance in terms of financial, customer, business process, and learning-and-growth outcomes, rather than exclusively by financial measures, to arrive at a more powerful view of near term and future performance. It advocates integration of these outcomes into corporations' strategic planning processes. The scorecard is a framework for collecting and integrating the range of metrics along the Impact Value Chain, and is adaptable to an organisation's stage. It helps coordinate evaluation, internal operations metrics, and external benchmarks, but is not a substitute for them. Recently Kaplan has adapted the Balanced Scorecard for non-profits, suggesting that such institutions adopt strategic performance measures that focus on user satisfaction (Clark et al. 2004).

http://www.balancedscorecard.org/

4 Best Available Charitable Option (BACO)

Based on internet information, accessed on 29 August 2009, http://blog.acumenfund.org/wp-content/uploads/2007/01/BACO%20Concept%20Paper_01.24.071.pdf

This system is developed by Acumen Fund in 2006

> Rather than seek an absolute standard for social return across an extremely diverse portfolio, Acumen Fund looks to quantify an investment's social impact and compare it to the universe of existing charitable options for that explicit social issue. Specifically, this tool

> BACO helps inform investors where their philanthropic capital will be most effective—answering "For each dollar invested, how much social output will this generate over the life of the investment relative to the best available charitable option?" The BACO ratio (for best available charitable option), must be seen as a starting point for assessing the social impact and cost-effectiveness of investments. The point of the analysis is to inform our portfolio decision-making with a quantifiable indication of whether our social investment will "outperform" a plausible alternative.

http://www.acumenfund.org

5 BoP Impact Assessment Framework

Based on internet information, accessed on 29 August 2009, http://www.wdi.umich.edu/files/Conferences/2007/BoP/Speaker%20Presentations/PDF/State%20of%20the%20Field%20(London%20Final).pdf

The Bottom of the Pyramid Impact Assessment Framework is developed by Ted London in 2007.

> The aim of the BoP Impact Assessment Framework is to understand who at the base of the pyramid is impacted by BoP ventures and how they are affected. The framework is developed to evaluate and articulate impacts, to guide strategy and to enable better investment decisions.
>
> Next to this the system contributes to a deeper knowledge of the relationship between profits and poverty alleviation and to recognize the poverty alleviation implications of different types of ventures. It builds upon the different well-being constructs as developed by 1998 Nobel Prize winner Amartya Sen.

http://www.wdi.umich.edu/

6 Center for High Impact Philanthropy Cost per Impact

Based on internet information, accessed on 29 August 2009, http://www.impact.upenn.edu/our_work/documents/WhatisHighImpactPhilanthropy_initialconceptpaperApril2007_000.pdf

This tool is developed by the Center for High Impacts Philanthropy from the University of Pennsylvania in 2007.

> High impact philanthropy means getting the most good for your philanthropic buck. It is the process by which a philanthropist makes the biggest difference possible, given the amount of capital invested. In order to assess cost per impact, philanthropists must be able to assess, to the extent possible, its two components: 1) social impact, as measured by specific, objective criteria for success; and 2) cost, as measured by the investments made by philanthropists or other sources to realise the impact. Assessment requires objective, reliable information on what's effective, what's not, and how much capital is required to achieve a given impact. The Center for High Impact Philanthropy aims to deliver the information and analytic tools required to answer these questions.

http://www.impact.upenn.edu

7 Charity Assessment Method of Performance (CHAMP)

Based on internet information, accessed on 29 August 2009 http://www.goededoelentest.nl/_shared/champ_juni_2007.pdf and http://www.goededoelentest.nl/_shared/champ_juni_2007.pdf

The CHAMP method is developed by the Dutch charities test (nationale goede doelen test) in 2006.

> The performance of charity's ADT are determined by effectiveness - What did we achieve? - And efficiency - how fast and in a cost-effective way? Effectiveness and efficiency can be measured on five distinct levels:
>
> 1. Impact on society: how is society is affected by the effect of the charity on their target group?
> 2. Impact on the public: in what way is the situation of the target group demonstrably improved by the output of the charity?
> 3. Output: what concrete results are produced by the core activities of the charity using the input factors (money, volunteers, etc.)?
> 4. Activities: how effective are the core activities of the charity?
> 5. Input: how effective and efficient are the activities related to the input factors such as fundraising and recruiting volunteers?'
>
> 'The CHAMP method provides indicators to measure the performance on all different levels. This tool is developed to help donators, and volunteers to choose between a wide range of non-profit corporations.

http://www.goededoelentest.nl

8 Foundation Investment Bubble Chart

Based on internet information, accessed on 1 August 2009, http://www.gumballuniversity.org/blog/start-a-venture/metrics-analytical-methods and http://www.gatesfoundation.org/learning/Documents/WWL-profiles-eight-integrated-cost-approaches.pdf

> This form of analysis is more of a visualization tool that plots the quantifiable impact on the x-axis, the percentage of implementation on the y-axis, and the relative size of a foundation's grant in a given field. This results in an easy comparison of the performance of corporations across a portfolio and can have different variables for the x-axis, y-axis and bubble relativity for flexible data display. Foundation board of directors and senior management teams could use the bubble chart to assess the relative performance and cumulative foundation investment (or total philanthropic investment) against the indices of performance they care about most. The analyses can be used to discuss performance, explore why one program or a group of programs are positioned where they are, and inform future investments.

9 Hewlett Foundation Expected Return

Based on internet information, accessed on 1 August 2009, http://www.gumballuniversity.org/blog/start-a-venture/metrics-analytical-methods and http://www.gatesfoundation.org/learning/Documents/WWL-profiles-eight-integrated-cost-approaches.pdf

This tool is developed by the William and Flora Hewlett Foundation. This foundation was founded in 1966 to solve social and environmental problems at home and around the world.

> The method calculates the expected return of investments and is developed to enable foundations To ask and answer the right questions for every investment portfolio: what‘s the goal? How much good can it do? Is it a good choice? How much difference will we make? What‘s the price tag? The method is purely prospective. The expected return provides a systematic, consistent, quantitative process for evaluating potential charitable investments, and is based heavily on cost-effectiveness analysis and cost-benefit analysis.

http://www.hewlett.org/

10 Local Economic Multiplier (LEM)

Based on internet information, accessed on 1 August 2009, http://www.sustainableseattle.org/conffolder/conffolder/VikiSonntagPresentation.ppt and http://www.applet-magic.com/LEM.htm

> The Economic Multiplier is an central concept in Keynesian and post-Keynesian ***economics. A*** multiplier is a factor of proportionality that measures how much an endogenous variable changes in response to a change in some exogenous variable.
>
> The local economic multiplier is based on the idea that dollars spend in locally-owned stores will impact the local economy two or three times more in comparison to dollars spend in national retailers. The basics of the local multiplier methodology are the identification of income in three rounds. The first round measures direct income of the study group, the second round measures indirect income, i.e. local spending of the study group, the third round measures induced income, i.e., local spending by local recipients of study group spending. The local multiplier is the sum of direct, indirect and induced income divided by direct income.

11 Measuring Impact Framework (MIF)

Based on internet information, accessed on 24 August 2009, http://businessfightspoverty.ning.com/profiles/blogs/what-gets-measured-gets-done and http://www.wbcsd.org/web/measuringimpact.htm

The Measuring Impact Framework is developed in 2008 by the World Business Council for Sustainable Development.

> The Measuring Impact Framework is designed to help corporations understand their contribution to society and use this understanding to inform their operational and long-term investment decisions and have better-informed conversations with stakeholders. The framework is based on a four-step methodology that attempts to merge the business perspectives of its contribution to development with the societal perspectives of what is important where that business operates. Step one, set boundaries: determine the scope and depth of the overall assessment in terms of geographical boundary (local versus regional) and types of business activities to be assessed. Step two, measure direct and indirect impacts: Identify and measure the direct and indirect impacts arising from the corporation’s activities, mapping out what impacts are within the control of the corporation

and what it can influence through its business activities. Step three, assess contribution to development. Assess to what extent the corporation's impacts contribute to the development priorities in the assessment areas. Step four, prioritise management response: based on steps two and three extract the key risks and opportunities relative to the corporation's societal impact, and based on this, develop an appropriate management response. There is no "one size fits all" way to use this methodology. In order to appropriately tailor the methodology to the business and its operating context, as well as ensure follow-up actions are taken, corporations are encouraged to make the assessment as participative as possible, consulting people both within and if possible external to the corporation.

http://www.wbcsd.org

12 Millennium Development Goal Scan (MDG-Scan)

Based on internet information, accessed on 1 August 2009, http://www.mdgscan.com/index.php?page=Textpage&item=contact_details#page=Textpage&item=about_scan

The MDG scan is developed in 2009 by the Dutch National Committee for International Cooperation and Sustainable Development (NCDO) and Dutch Sustainability Research (DSR).

The MDG Scan is a tool designed for corporations to measure the positive contribution tot the Millennium Development Goals (MDGs) and demonstrate their role in the global initiative to reach these eight MDGs. The MDG Scan measures each corporation's MDG impact by entering key data in a secured environment. Once the corporation approves the publication of its results, they will be visible for everyone. The MDG Scan is a practical tool for corporations. Without spending much time or effort, corporations can gain insight in their MDG Footprint. Based on key data on core business and community investment activities that can be entered after registering, the MDG scan estimates your corporation's contribution to each of the MDGs. Real time results generation quickly provides easy-to-understand insights, globally, per country or per sector/industry. Each corporation can download a personalized MDG impact results report, which facilitates internal discussions and in-depth analysis of its MDG impact.

http://www.mdgscan.com

13 Volunteering Impact Assessment Toolkit

Based on internet information, accessed on 1 August 2009, http://www.socialeconomyscotland.info/scvo/content/pilot/impact.asp and http://ecommerce.volunteering.org.uk/PublicationDetails.aspx?ProductID=V309

The Volunteering Impact Assessment Toolkit was developed in 2004 by the Institute of Volunteering Research (IVR) with input from the London School of Economics, The University of East London and Roehampton University. It is widely recognised that volunteers make a difference to the work of many social economy corporations, but this is mainly supported by anecdotal evidence. The Toolkit is a way of changing this. It is easy to use, comprehensive and adaptable. It allows corporations to look at the impact of volunteering on the volunteer, the service user, the corporation and the wider community. It can help corporations gain a greater understanding of how and why volunteering works in the corporation as well as gather evidence to support funding bids.

This new toolkit will enable corporations to assess the impact of volunteering on all key stakeholders: the volunteers, the corporation, the beneficiaries, and the broader community. Results over time can be compared. Corporations will be able to use it to assess a wide range of impacts, from the skills development of volunteers to the economic value of volunteering corporations. Positive and negative results, intended and unintended impacts can be explored.

http://www.volunteering.org.uk

14 Ongoing Assessment of Social Impacts (OASIS)

Adapted from a description in Clark et al. 2004

Developed in 1999 by REDF (formerly The Roberts Enterprise Development Fund) a nonprofit enterprise that creates job opportunities through support of social enterprises that help people gain the skills to help themselves.

REDF developed this system for its internal use and that of the nonprofit agencies in its portfolio to assess the social outputs and outcomes of the agencies overall, including the social enterprises they each operate. The system is a customised, comprehensive, ongoing social management information system (MIS). It entails both designing an information management system that integrates with the agency's information tracking practices and needs, and then implementing the tracking process to track progress on short- to medium term (two years) outcomes.

http://www.redf.org/

15 Participatory Impact Assessment

Based on internet information, accessed on 24 August 2009, http://wikis.uit.tufts.edu/confluence/display/FIC/Participatory+Impact+Assessment--+a+Guide+for+Practitioners and http://www.devnet.org.nz/conf2002/abstracts/Nowland-Foreman_Sandra.pdf

The Feinstein International Center has been developing and adapting participatory approaches to measure the impact of livelihoods based interventions since the early nineties. Participatory Impact Assessment (PIA) takes the participatory methodology of these processes and applies it to the original corporational objectives in asking the critical questions "what difference are we making?" PIA offers not only a useful tool for discovering what change has occurred, but also a way of understanding why it has occurred. The framework does not aim to provide a rigid or detailed step by step formula, or set of tools to carry out project impact assessments, but describes an eight stage approach, and presents examples of tools which may be adapted to different contexts. A guide for practitioners is available

> to demonstrate how PIA can be used to overcome some of the inherent weaknesses in conventional humanitarian monitoring evaluation and impact assessment approaches, such as; the emphasis on measuring process as opposed to real impact, the emphasis on external as opposed to community based indicators of impact, and how to overcome the issue of weak or non-existent baselines.

http://wikis.uit.tufts.edu/confluence/display/FIC/Feinstein+International+Center

16 Poverty Social Impact Assessment (PSIA)

Adapted from a description in Clark et al. 2004.

This system has been developed by the World Bank in 2000.

> PSIA is a systematic analytic approach to "the analysis of the distributional impact of policy reforms on the well-being of different stakeholder groups, with a particular focus on the poor and vulnerable…" (PSIA User's Guide). It is not a tool for impact assessment in and of itself, but is rather a process for developing a systematic impact assessment for a given project. Its components are not new, but PSIA has been formally articulated as a systematic approach by the World Bank in 2003. The method emphasises the importance of setting up the analysis by identifying the assumptions on which the program is based, the transmission channels through which program effects will occur, and the relevant stakeholders and institutional structures. Then program impacts are estimated, and the attending social risks are assessed, using analytical techniques that are adapted to the project under study.

http://www.worldbank.org/psia

17 Public Value Scorecard (PVSc)

Based on internet information, accessed on 24 August 2009, http://www.exinfm.com/workshop_files/public_sector_scorecard.pdf

The Public Value Scorecard is developed in 2003 by Prof. M.H. Moore, Director of the Hauser Center for Nonprofit Corporations at the John F. Kennedy School of Government at Harvard University.

> The Public Value Scorecard is based on the concept of the Balanced Scorecard. All the basics of the Balanced Scorecard– that non-financial measures are important, that process measures are important as well as outcome measures, that a measurement system ought to support the execution of an agreed upon strategy – are used but put to work through the use of strategic concept that seems more appropriate to nonprofits. The ultimate goal of non-profits is not to capture and seize value for themselves, but to give away their capabilities to achieve the largest impact on social conditions that they can, and to find ways to leverage their capabilities with those of others. There are three crucial differences between the BSc and the PVSc. First, in the public value scorecard, the ultimate value to be produced by the organisation is measured in non-financial terms. Second, the public value scorecard focuses attention not just on those customers who pay for the service, or the clients who

benefit from the organisation's operations; it focuses as well on the third party payers. Third, the public value scorecard focuses attention on productive capabilities for achieving large social results outside the boundary of the organisation itself.

18 Robin Hood Foundation Benefit–Cost Ratio

Based on internet information, accessed on 29 August 2009, http://www.robinhood.org/media/121827/q1_2006.pdf and http://www.partnershipforsuccess.org/docs/ivk/iikmeeting_slides200711weinstein.pdf

The Robin Hood benefit–cost ratio was developed by the Robin Hood Foundation in 2004.

> In 2004, we determined that for truly effective grant making, we needed to know the value of similar and dissimilar programs. For example, is a certain job training program a better investment than a particular education program? To answer this question, Robin Hood developed an innovative methodology of evaluation, or metrics. First, a common measure of success for programs of all types is applied: how much the program boosts the future earnings (or, more generally, living standards) of poor families above that which they would have earned in the absence of Robin Hood's help. Second, a benefit/cost ratio is calculated for the program—dividing the estimated total earnings boost by the size of Robin Hood's grant. The ratio for each grant measures the value it delivers to poor people per dollar of cost to Robin Hood—comparable to the commercial world's rate of return.

http://www.robinhood.org

19 Social Compatibility Analysis (SCA)

Based on internet information, accessed on 29 August 2009 http://www.ifib.uni-karlsruhe.de/web/ifib_dokumente/downloads/bfs_abstract.pdf

This tool has been developed in 2003 by the Institute for Sustainable Development at the Zurich University of Applied Sciences Winterthur (ZHW), Switzerland.

> The Social Compatibility Analysis (SCA). This method defines objective criteria according to which social compatibility is evaluated. First, the user of the SCA-tool divides a system into a number of subsystems, i.e. a product could be divided into subsystems according to the life cycle phases preproduction, production, use and disposal. Second, relevant evaluation criteria are selected. Finally, subsystems should be assigned to classes A (highly relevant social problems), B (of medium relevance), C (of low relevance) or 'not relevant' for all the chosen criteria. The SCA is useful when the social dimension of a project is concerned, when the clarification of differing stakeholder opinions is needed or when sets of solutions are to be negotiated.

http://zsa.zhwin.ch

20 Social Costs–Benefit Analysis (SCBA)

Adapted from a description in Clark et al. 2004.

This is a general economic tool for performance measurement. Since the 1990s the traditional cost–benefit analysis has been extended to include impacts upon the society.

> Social cost-benefit analysis is a type of economic analysis in which the costs and social impacts of an investment are expressed in monetary terms and then assessed according to one or more of three measures: (1) net present value (the aggregate value of all costs, revenues, and social impacts, discounted to reflect the same accounting period; (2) benefit-cost ratio (the discounted value of revenues and positive impacts divided by discounted value of costs and negative impacts); and (3) internal rate of return (the net value of revenues plus impacts expressed as an annual percentage return on the total costs of the investment.

21 Social Cost-Effectiveness Analysis (SCEA)

Based on internet information, accessed on 29 August 2009 http://www.caps.ucsf.edu/pubs/FS/costeffectiverev.php

The term cost-effectiveness analysis refers to the economic analysis of an intervention. This is a general economic tool for performance measurement. Since the 1990s the traditional cost-effectiveness analysis has been extended to include impacts upon the society.

> For example, one measure of cost-effectiveness is the cost per HIV infection averted. This is affected by many factors: intervention cost, number of people reached, their risk behaviors and HIV incidence, and the effectiveness of the intervention in changing behavior. The purpose of cost-effectiveness analysis is to quantify how these factors combine to determine the overall value of a program. Cost-effectiveness analysis can determine if an intervention is cost-saving (cost per HIV infection averted is less than the lifetime cost of providing HIV/AIDS treatment and care) or cost-effective (cost per HIV infection averted compares favorably to other health care services such as smoking cessation or diabetes detection).

Cost-effectiveness analyses also break down the costs and resources needed to implement interventions—personnel, training, supplies, transportation, rent, overhead, volunteer services, etc.

22 Social e-Valuator

Based on internet information, accessed on 1 August 2009 http://www.socialevaluator.eu/SROItool.aspx

The social e-valuator is developed in 2007 by the d.o.b. Foundation and the Noaber Foundation and Scholten Franssen, a Dutch consultancy corporation.

The social e-valuator is a web-tool based on the SROI methodology. For further description see description of SROI.

http://www.socialevaluator.eu

23 Social Footprint

Based on internet information, accessed on 1 August 2009, http://www.sustainableinnovation.org/Social-Footprint.pdf

> The social footprint is a measurement and reporting method that corporations can use to manage, measure and report the sustainability of their impacts on people and society in a broad range of areas. It is a context-based measurement tool that takes actual human and social conditions in the world into account as a basis for measuring the social sustainability performance of corporations. The Social Footprint might be seen as an adaptation of the concept of ecological footprint. Both footprints are alike in the sense that both are about measuring gaps, but the similarity ends there. In the case of the Ecological Footprint, the gaps of interest to us are between resources we need and resources we are stuck with; in the case of the Social Footprint, the gaps of interest to us are between resources we need and resources we have decided to produce. Ecological resources are fixed and limited, social resources are not. The sustainability metrics make it possible to measure non-financial organisational performance (e.g., the triple bottom line) against standards of performance. Numerators express actual impacts on vital capitals in the world, and denominators express norms for what such impacts ought to be in order to ensure human well-being.

http://www.sustainableinnovation.org/

24 Social Impact Assessment (SIA)

Based on internet information, accessed on 1 August 2009, http://www.st.nmfs.noaa.gov/tm/spo/spo16.pdf and http://www.dams.org/docs/kbase/contrib/ins220.pdf

> The concept of SIA is understood to include adaptive management of impacts, projects and policies (as well as prediction, mitigation and monitoring) and therefore needs to be involved (at least considered) in the planning of the project or policy from inception. The SIA process can be applied to a wide range of interventions, and undertaken at the behest of a wide range of actors, and not just within a regulatory framework. It is implicit that social and biophysical impacts (and the human and biophysical environments) are interconnected. The overall purpose of all impact assessment is to bring about a more sustainable world, and that issues of social sustainability and ecological sustainability need to be considered in partnership. SIA is also understood to be an umbrella or overarching framework that embodies all human impacts including aesthetic impacts (landscape analysis), archaeological (heritage) impacts, community impacts, cultural impacts, demographic impacts, development impacts, economic and fiscal impacts, gender assessment, health impacts, indigenous rights, infrastructural impacts, institutional impacts, political impacts (human rights, governance, democratisation etc), poverty assessment, psychological impacts, resource issues (access and ownership of resources), tourism impacts, and other impacts on societies.

http://www.socialimpactassessment.net/

25 Social Return Assessment (SRA)

Adapted from a description in Clark et al. 2004.

This system was developed in 2000 by Pacific Community Ventures (PCV), a nonprofit organisation that manages two for-profit investment funds that invest in corporations that provide jobs, role models, and on-the-job training for low-income people, and that are located in disadvantaged communities in California.

> PCV developed the method for its own use in assessing the social return of each investor and of its portfolio overall. The system entails tracking progress specifically on the number and quality of jobs created by PCV's portfolio corporations. It helps the fund target and improve its services to its investors and to a group of corporations to which it provides business advisory services. The method is separate from financial performance assessment.

http://www.pacificcommunityventures.com/

26 Social Return on Investment (SROI)

Adapted from a description in Clark et al. 2004.

Developed in 1996 by REDF (formerly The Roberts Enterprise Development Fund) a nonprofit enterprise that creates job opportunities through support of social enterprises that help people gain the skills to help themselves.

> REDF developed social return on investment (SROI) analysis to place a dollar value on ventures in its portfolio with social as well as market objectives. The approach combines the tools of benefit-cost analysis, the method economists use to assess non-profit projects and programs, and the tools of financial analysis used in the private sector. Conceptually, the approach differs from these established types of analysis, notably in what is considered a "social" benefit. Practically, it is more accessible to a broad range of users, substituting readily understood terms and methods for technical jargon and complicated techniques.

http://www.redf.org/

27 Socioeconomic Assessment Toolbox (SEAT)

Based on internet information, accessed on 1 August 2009 http://www.angloamerican.co.uk/aa/development/society/engagement/seat/ and http://www.angloamerican.co.uk/corporateresponsibility

The Socioeconomic Assessment Toolbox was first launched in 2003 by Anglo American plc.

> The toolbox builds on several steps. (1) profiling our own operations and our host community, (2) identifying and engaging with key stakeholders, (3) assessing the impacts of our operations – both positive and negative – and the community's key socio-economic development needs, (4) developing a management plan to mitigate any negative aspects of our presence and to make the most of the benefits our operations bring, (5) working with stakeholders and communities to help address some of their broader development challenges

they would face even without our presence, (6) producing a report with stakeholders to form the basis for ongoing engagement with and support for the community.

http://www.angloamerican.co.uk/

28 Stakeholder Value Added (SVA)

Adapted from a description in Schaltegger et al. (2002).

Stakeholder value analysis is based on the stakeholder approach or standard-setting and strategic management of corporations, which is used to analyse relations between stakeholders (interest groups) and corporations. Measuring the contribution to corporation value due to stakeholder relations (stakeholder value) is done in four steps. In the first two steps, the return on stakeholder (RoSt) is calculated for the corporation in question and the reference corporation (e.g.market average). The RoSt represents the stakeholder's relative contribution to the value of the corporation. In the third step the RoSt of the reference corporation is subtracted from the RoSt of the corporation in view. In the final step this is multiplied by the corporation's stakeholder costs to obtain the stakeholder value added.

http://www.uni-lueneburg.de/csm

29 Toolbox for Analysing Sustainable Ventures in Developing Countries

Based on internet information, accessed on 1 August 2009 http://www.roap.unep.org/pub/TowardstripleimpactEN.pdf

The toolbox for analysing sustainable ventures in Developing Countries is developed by UNEP (United Nations Environmental Programme) in 2009.

The toolbox is developed to answer questions related to the identification of opportunities, the understanding of the determinants of success and the assessment of costs and benefits appear repeatedly. It addresses initiatives that support sustainable ventures including donor programmes, award schemes, private and public investors, professional education programs and policy makers. They can use the tools to systematically identify, evaluate, advice, and promote sustainable ventures. The tools respond to three questions that appear over and again in the process of building and managing a sustainable venture:

- Where are opportunities to create value • by meeting needs better and more efficiently?
- What factors determine the success of the venture?
- What are costs and benefits of the venture for the business, society and the environment?

http://www.unep.org

30 Wellventure Monitor™

Based on internet information, accessed on 1 August 2009 http://www.wellventuremonitor.nl/About.aspx?Num=0

The Wellventure Monitor™ is developed in 2006 by the Fortis Foundation Netherlands (FFN) and the Erasmus University Rotterdam (EUR).

> The Wellventure Monitor™ measures the effects of community investment on several aspects. It makes clear what the target group benefits from the project, but also what the corporation, the employees, and the social organisation gains from it. The Wellventure Monitor™ provides insight into the effects of a specific project. But more importantly; it is also possible to see the sum of the different projects. This way, the long-term benefits of community investment become visible. With the tool, corporations and corporations can create a survey after finishing a project and send it to those involved at the corporation, employees of the organisation, and to the target group. The surveys are processed automatically. The tool can be used to view, analyze, and present the results. Per project, or over a longer period of time.

http://www.wellventuremonitor.nl

References

Aguilera RV, Rupp DE, Williams CA and Ganapathi J (2007) Putting the s back in corporate social responsibility: A multilevel theory of social change in organizations *The Academy of Management* 32.3 836–863

Ann KB, Allen CA and Matthew AR (1999) Beyond resources: The mediating effect of top management discretion and values on corporate philanthropy *Business and Society* 38.2 167–187

Ben-Ner A and v. Hoomissen T (1992) An empirical investigation of the joint determination of the size of for-profit, nonprofit and governmental sectors *Annals of Public and Cooperative Economics* 63.3 392–415

Boyne G (2002) Public and private management: What's the difference? *Journal of Management Studies* 39.1 97–121

Burdge RJ and Vanclay F (1996) Social impact assessment: A contribution to the state of the art series *Environmental and Social Impact Assessment* 14 59–86

Burritt RL and Saka C (2006) Environmental management accounting applications and eco-efficiency: Case studies from Japan *Journal of Cleaner Production* 14.14 1262–1275

Clark C, Rosenzweig W, Long D and Olsen S (2004) *Double Bottom Line Project Report: Assessing Social Impact in Double Bottom Line Ventures; Methods Catalog, Viewed 28 May 2010* [online] Available from Internet URL <http://www.shidler.hawaii.edu/Portals/1/resources/DoubleBottomLine.pdf>

Conner KR (1991) A historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm? *Journal of Management* 17.1 121–154

de Bakker FGA, Groenewegen P and den Hond F (2005) A bibliometric analysis of 30 years of research and theory on corporate social responsibility and corporate social performance *Business and Society* 44.3 283–317

Dentchev NA (2004) Corporate social performance as a business strategy *Journal of Business Ethics* 55.4 395–410

Ebrahim A (2005) *NGOs and Organizational Change: Discourse, Reporting, and Learning* Cambridge, Cambridge University Press

Eccles RG (1991) The performance measurement manifesto *Harvard Business Review* 69.1 131–137

Elkington J (1999) *Cannibal with Forks, The Triple Bottom Line of 21st Century Business* Oxford, Capstone

Elkington J, Emerson J and Beloe S (2006) The value palette: a tool for a full spectrum strategy *California Management Review* 48.2 6–28

Emerson J, Wachowicz J and Chun S (2000) *Social Return on Investment: Exploring Aspects of Value Creation in the Non-Profit Sector* San Francisco, The Roberts Foundation

Emerson J (2003) The blended value proposition: Integrating social and financial returns *California Management Review* 45.4 35–51

Epstein MJ (2008) *Making Sustainability Work: Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts* Sheffield, Greenleaf Publishing Ltd.

Forbes DP (1998) Measuring the unmeasurable: Empirical studies of nonprofit organization effectiveness from 1977 to 1997 *Nonprofit and Voluntary Sector Quarterly* 27.2 183–202

Freudenburg WR (1986) Social impact assessment *Annual Review of Sociology* 12.1 451–478

Friedman M (1970) The social responsibility of business is to increase its profits *The New York Times Magazine* (September 13) 32–33, 122, 126

Fry LW, Keim GD and Meiners RE (1982) Corporate contributions: Altruistic or for-profit? *The Academy of Management Journal* 25.1 94–106

Gentile MC (2000) *Social Impact Management, a Definition* Discussion Paper II Aspen ISIB: The Aspen Institute [online] [Cited 28 May 2010] Available from Internet URL <http://www.aspenisib.org>

GRI (2006) *Sustainability Reporting Guidelines (G3)* Amsterdam, Global Reporting Initiative

Husted BW and de Jesus Salazar J (2006) Taking Friedman seriously: Maximizing profits and social performance *Journal of Management Studies* 43.1 75–91

IPC (2008) *PSIA Gauging Poverty Impacts* Poverty in Focus series 14 Brasilia, International Poverty Centre

IPIECA (2008) *Creating Successful, Sustainable Social Investment; Guidance Document for the Oil and Gas Industry* London, International Petroleum Industry Environmental Conservation Association

Ittner CD and Larcker DF (1998) Innovations in performance measurement: Trends and research implications *Journal of Management Accounting Research* 10 205–238

Juholin E (2004) For business or the good of all? A Finnish approach to corporate social responsibility *Corporate Governance* 4.3 20–31

Kolodinsky J, Stewart C and Bullard A (2006) Measuring economic and social impacts of membership in a community development financial institution *Journal of Family and Economic Issues* 27.1 27–47

Labuschagne C, Brent AC and van Erck RPG (2005) Assessing the sustainability performances of industries *Journal of Cleaner Production* 13.4 373–385

Lamberton G (2005) Sustainability accounting – a brief history and conceptual framework *Accounting Forum* 29.1 7–26

Latané B (1981) The psychology of social impact *American Psychologist* 36.4 343–356

Lepak DP, Smith KG and Taylor MS (2007) Value creation and value capture: A multilevel perspective *Academy of Management Review* 32.1 180–194

Loew T (2003) Environmental cost accounting: Classifying and comparing selected approaches *in* Bennett M, Rikhardsson PM and Schaltegger S *Environmental Management Accounting – Purpose and Progress* Dordrecht, Kluwer Academic Publishers 41–56

Loew T, Fichter K, Müller U, Schultz WF and Strobel M (2001) *Ansätze der umweltkostenrechnung im vergleich – unveröffentlichter endbericht* Berlin (available only in German)

London T (2009) Making better investments at the base of the pyramid *Harvard Business Review* 87.5 106–113

Maas KEH and Bouma JJ (2005) Sociale meerwaarde van MVO: Een welvaartseconomisch perspectief *in* Dentchev NA, Heene A, Herstroter CAJ and de Graaf FJ (*Maatschappelijk verantwoord ondernemen, pragmatisch bekeken*) Gent, Academia Press 125–137 (available only in Dutch)

Maas KEH and Boons F (2010) CSR as a strategic activity: value creation, integration and redistribution *in* Louche C, Idowu SO and Filho WL *Innovative CSR* Sheffield, Greenleaf Publishing 154–172

Margolis JD and Walsh JP (2003) Misery loves corporations: Rethinking social initiatives by business *Administrative Science Quarterly* 48.2 268–305

Matten D, Crane A and Chapple W (2003) Behind the mask: Revealing the true face of corporate citizenship *Journal of Business Ethics* 45.1 109–120

McWilliams A and Siegel D (2000) Corporate social responsibility and financial performance: Correlation or misspecification? *Strategic Management Journal* 21.5 603–609

McWilliams A and Siegel D (2001) Corporate social responsibility: A theory of the corporation perspective *The Academy of Management Review* 26.1 117–127

Pearce D, Atkinson G and Mourato S (2006) *Cost–Benefit Analysis and the Environment: Recent Development* Paris, OECD Publishing

Pearce D, Turner RK and Bateman I (1994) *Environmental Economics, an Elementary Introduction* London, Harvester Wheatsheaf

Porter ME and Kramer MR (2006) Strategy and society: The link between competitive advantage and corporate social responsibility *Harvard Business Review* 84.12 76–92

Schaltegger S and Burritt R (2000) *Contemporary Environmental Accounting, Issues, Concepts and Practice* Sheffield, Greenleaf Publishing

Schaltegger S, Hahn T and Burritt R (2000) *Environmental Management Accounting – Overview and Main Approaches* Working paper Lunenburg, Centre for Sustainability Management

Schaltegger S, Herzig C, Kleiber O and Muller J (2002) *Sustainability Management in Business Enterprises: Concepts and Instruments for Sustainable Corporation Development* Luneburg, Centre for Sustainability Management

Shell (2008a) *Managing Social Performance, Delivering Benefits* Confidential, Den Haag

Shell (2008b) *Managing Social Performance, Measuring and Communicating Social Performance* Confidential, Den Haag

US-EPA (1995) *An Introduction to Environmental Accounting as a Business Management Tool* Washington, DC, United States Environmental Protection Agency

Verwaal E, Commandeur HR and Verbeke W (2009) Value creation and value claiming in strategic outsourcing decisions: A resource-contingency perspective *Journal of Management* 35.2 420–444

Wainwright S (2002) *Measuring Impact: A Guide to Resources* London, NCVO Publications

Weisbrod B (1988) *The Non-Profit Economy* Cambridge, Harvard University Press

Wikipedia (2008) [online] [Cited on 28 may 2010] Available from Internet URL <http://en.wikipedia.org/wiki/Social_impact_assessment>

Zimmerman JL (2009) *Accounting for Decision Making and Control* New York, McGraw-Hill Education

Part IV
Economic Issues

Chapter 9
New Decision Method for Environmental Capital Investment

Norio Minato

Abstract The purpose of this chapter is to establish a decision-making method for evaluating capital investments in environmentally friendly projects. This method enables management decisions to be made appropriately under highly volatile conditions while promoting good corporate environmental behaviour. This chapter contributes to expand decision-making methods for environmental capital investment in environmental accounting. There are two challenges in establishing this method. The first is to convert environmental impact reduction into internal corporate value creation, which is done using the life-cycle impact assessment method based on endpoint modelling (LIME) tool described in the chapter. The second is to incorporate management decision flexibility in the appraisal of environmental investment, which is done using real options theory. The total economic value of the environmentally friendly projects then includes net present value, environmental impact reduction value and managerial flexibility value.

This chapter describes how this new environmental investment decision-making method was applied to a hybrid vehicle project in order to verify its effectiveness. The result indicates that the project which appears unattractive when evaluated using existing methods can be shown as attractive when this method is applied. It is considered that this method can contribute to the promotion of innovative environmentally friendly projects.

Keywords Environmental investment • Environmental accounting • Life-cycle impact assessment method based on endpoint modelling • Real options • Uncertainty

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1 Introduction

The issue of greenhouse gases (GHG) is one of the most critical facing the world. The meeting of the Group of 8 in Japan adopted a target of GHG reduction of 50% or more by 2050, which it considered is required for the realisation of a low-carbon society. This will heavily impact every company's business in future and is a critical issue that corporate management must confront. Furthermore, the price of crude oil was around $40 per barrel in 2004, peaked at $145 per barrel in 2008, then drastically dropped because of the global economic recession; so, the market price of gasoline has been significantly volatile. Because of these factors, consumer demand is pushing for innovative environmentally friendly products such as hybrid and electric vehicles (HEV) which combine an internal combustion engine and one or more electric motors.

Corporate management understands that innovative environmentally friendly products which contribute to reduce GHG are indispensable for the conservation of the global environment but also require an enormous amount of capital investment and face huge uncertainties – not only technical but business uncertainties. Management of GHG is usually therefore accompanied by a deterioration of cash flow in the short-term due to the huge investment and not guaranteed a return even in the medium- and long-term.

Theoretically, if a project offers a positive net present value (NPV), then in an efficient capital market it will add value for existing shareholders by causing an immediate increase in share price. However, it is well accepted that innovative environmentally friendly projects may have a negative NPV and so may seem unattractive to shareholders; company management's incentive to invest in them may be weakened.

Schaltegger (2008) demonstrates that creating a business case for sustainability requires a good understanding of links between non-monetary social and environmental activities on the one hand, and business or economic success on the other. The core question, and the basis for any business case for sustainability, is how profit resulting from increased social and environmental activities can be identified and managed. So, management needs to assess appropriately the economic value created by innovative environmentally friendly projects.

To assess the economic value created through environmental investments, the Japanese Ministry of Economy, Trade and Industry (2002) has established a method for capital investment in environmentally friendly facilities. They recommend using a table to compare alternatives and which incorporates not only the economic assessment, such as NPV, but also the environmentally harmful substance reduction benefits such as GHG reduction. Management then has to make a decision based on both the financial value and physical value. By contrast, the United States EPA (1992) has recommended the total cost assessment (TCA) method. This is designed to assist in the cost comparison of one or more pollution prevention alternatives to a current industrial practice, and sets up a hierarchy of costs as follows:

- Tier 0: Usual Costs
- Tier 1: Hidden Costs
- Tier 2: Liability Costs
- Tier 3: Less Tangible Costs

The hierarchy progresses from the most conventional and certain costs in Tier 1 through to the most difficult to estimate and least certain costs in Tier 3. The user first analyses all costs associated with the current and alternative projects and then calculates key financial indicators of the economic viability of the alternative projects. Financial calculations are added for each tier in sequence until the result concludes that some alternative meets the investment criteria of the corporation, or until all tiers have been completed. Kokubu (2000) argues that the advantage of this method is to evaluate the value of the environmental investment at a high level and to expand the acceptable scope of the environmental investment. However, these methods cover only the internal costs that have a direct impact on a company's profit, and do not bring into consideration the effect of corporate environmental behaviour on competitive position, – revenue enhancement and the prospects of appealing to green consumers and investors – or the value of flexibility.

The purpose of this chapter is to establish a decision-making method for capital investment in environmentally friendly projects which enables management decisions to be made appropriately under highly volatile conditions while promoting good corporate environmental behaviour. The best method for controlling management environmental behaviour is through financial assessment, including the value of the environmental element through corporate environmental behaviour and the value of company management's decision flexibility. Also, this chapter contributes to expand decision making methods for environmental capital investment in environmental accounting. Section 2 describes the theory of total economic value; Sect. 3 describes the empirical approach taken here; Sect. 4 presents a sensitivity analysis of each parameter; and, finally, Sect. 5 provides conclusions, limitations and future challenges.

2 Theory

Theoretically, in an efficient capital market, a project which offers a positive NPV should add value for shareholders by causing an immediate increase in share price which provides management with an incentive to make the investment. However, if a project has a negative NPV and the market does not immediately incorporate environmental elements and management's flexibility, then managerial incentives to invest in environmentally friendly projects are weakened and so it is necessary to develop a decision-making method which will enhance these incentives in both the short and long-term.

On the assumption that the market is prepared to incorporate the effect of environmental elements and managerial flexibility in share prices, an investment appraisal model which incorporates these factors is developed. To realise the investment appraisal model, there are two challenges in establishing a decision-making method for environmentally friendly projects. The first is corporate value creation from environmental impact reduction by which the social environmental value which is created by environmental investment, i.e. the reduction in environmental impacts, can be converted into internal corporate value creation. This is assessed by using the life-cycle impact assessment method based on endpoint modelling (LIME). The second is to incorporate management decision flexibility into the appraisal of environmental investment, which is undertaken using real options theory.

The total economic value of environmentally friendly projects includes the standard NPV, the environmental impact reduction value, and the managerial flexibility value. The formula is shown in Eq. 9.1.

$$\begin{aligned}\text{Total economic value} = {} & \text{Standard NPV} \\ & + \text{Environmental impact reduction value} \\ & + \text{Managerial flexibility value}\end{aligned} \tag{9.1}$$

2.1 Standard NPV

The NPV method of evaluating a project helps to find the present value (PV) in today's dollars of its future net cash flows. There are two steps in determining NPV: first, to determine PV and second, to determine NPV.

Step 1: Estimation of the project's PV

The PV is obtained by dividing the cash flow after deducting capital investment by (1 + WACC). The formula is shown in Eq. 9.2.

$$\mathrm{PV} = \sum_{i=1}^{n} \frac{\mathrm{CF}i}{(1+\mathrm{WACC})^{i}} \tag{9.2}$$

where
PV – Present value of the project's future cash inflows
CF – Cash flow after deducting capital investment
WACC – Weighted Average Cost of Capital
i – Time period

Step 2: Estimation of the project's NPV

The NPV is obtained by deducting from the result of Step 1, the PV of the capital investment that is required which is obtained by dividing the capital investment by (1 + risk-free rate) from the PV. The formula is shown in Eq. 9.3.

$$\mathrm{NPV} = \mathrm{PV} - \sum_{i=1}^{n} \frac{Ii}{(1+\mathrm{rf})^{i}} \tag{9.3}$$

where
NPV – Net present value
I – Capital investment per time period
rf – Risk-free rate
i – Time period

2.2 Environmental Impact Reduction Value

The first challenge is corporate value creation from environmental impact reduction. This section provides a review of the literature on existing research into corporations' motives for investing in environmentally friendly projects. Lyon and Maxwell (1999) argue that corporations can differentiate their products by improving their environmental qualities and thereby charge a higher price and that green investors may be an increasingly important factor in determining corporate environmental activity. Williamson et al. (2006) identify two possible motives for corporate environmental behaviour: a business case motive and a business performance motive. The former refers to the corporation appealing to green consumers and investors, whereas the latter refers to cost reduction and efficiency. Chen et al. (2006) show through a case study in Taiwan that the performance of green product innovation and green process innovation are positively correlated to competitive advantage. Fairchild (2008) uses a game-theoretic approach to demonstrate that the size of the investment cost and the extent of consumer and investor green awareness affect corporate incentives to make environmental investments. Auger et al. (2003) provide an estimation of the relative value which selected consumers place on the social features of products, using a distinctive method. Machlachlan and Gardner (2004) indicate some important differences between socially responsible and conventional investors in their beliefs on the importance of ethical issues, their investment decision-making style and their perceptions of moral intensity. Kokubu (1999) suggests that green stakeholders, such as green consumers, consider environmental impacts of purchased products and green investors appreciate corporate actions and corporate policies toward environmental conservation and will accept additional cost and investment in environmental conservation if this is justified by the reduction of environmental impact.

The implication of these previous papers is that value from environmental investments can be created by attracting green consumers who are willing to pay a product price premium and by attracting green investors who are willing to pay a share price premium. Green stakeholders, such as green consumers and green investors, accept the price premium equivalent to the economic value of environmental impact reduction. This aspect can then be brought into the investment appraisal calculation. In other words, the social environmental value creation from environmental investment can be converted into internal corporate value creation.

The economical value of the environmental impact reduction is assessed by LIME. This is a life-cycle impact assessment method developed as part of a Japanese national project from 1988 through 2003. LIME has been designed to comply with ISO 14042 and to enable life-cycle impact assessment (LCIA) that reflects Japan's environmental conditions and environmental ideology, in three types of steps: characterisation, damage assessment and weighting. Itsubo and Inab (2005) disclose the methodology and value lists for each environmentally harmful substance. The assessment of social economic impact due to environmentally harmful substances assessment can therefore be done without specialist knowledge. The formula of LIME is shown in Eq. 9.4.

$$SI = \sum_{IS} \sum_{S} IF_{S,IS} \times Inv_{S} \tag{9.4}$$

where

SI – Social economic impact due to environmentally harmful substances

IF – Social economic impact per amount of weight for each impact category and each harmful substance

Inv – Amount of weight of harmful substance

IS – Each impact category such as GHG, acid rain and so on

S – Each harmful substance such as carbon dioxide (CO_2), nitrogen oxide (NO_x) and so on

2.3 *Managerial Flexibility Value*

The second challenge is to incorporate decision flexibility into the appraisal of environmental investment. The NPV method treats NPV as a fixed value at the time of decision-making, and uncertainties after decisions have been made are treated as business risks. Mun (2003) identifies certain issues that are inherent in the NPV method as follows. The first is that despite the fact that future results are uncertain, decisions are made and the future is treated as fixed. The second is that despite the fact that it is often difficult to estimate future cash flows, future possibilities are treated as determined. The third is that despite the fact that risks that will be encountered in the future are subject to change, it is assumed that all risks can be covered by adopting a discount rate. Trigeorgis (2001) describes managerial flexibility as adapting to a new situation by modifying the original plan in response to unexpected changes in the market. Passive managements are obsessed with initial expectations, but active managements may change their initial decisions when they can limit downside loss or increase upside profit. Smit and Trigeorgis (2006) indicate that the management has flexibility to proceed with, abandon, enhance, or shrink, its future plan compared to the original plan and has a right to acquire an asset for a specified price at some future time. Techniques derived from option pricing can help in quantifying management's ability to adapt future plans in order to capitalise on favourable investment opportunities or to respond to undesirable developments in a dynamic environment by cutting losses.

Management has the option to discontinue a project if market conditions turn out to be unfavourable. This means that through managerial flexibility, uncertainties can be converted into economic value as option value. Instead of the NPV method which does not take managerial flexibility into consideration, the option value method can incorporate managerial flexibility and is considered to be an effective method to qualify more accurately, the economic value of capital investment in environmentally friendly projects.

Myers and Majd (1990) indicate that the abandonment option is equivalent to an American "put" option with both an uncertain underlying stock value (cash flows) and an uncertain exercise price (exit value). Berger et al. (1996) developed a hypothesis that determines the abandonment option value. This hypothesis is explained through Eqs. 9.5, 9.6 and 9.7.

$$\mathrm{VALUE} = \mathrm{PVCF} + \mathrm{P}(\mathrm{PVCF}, \mathrm{EXIT}, \mathrm{SDEV}) \tag{9.5}$$

$$\mathrm{PVFCF} = \sum_{t=1}^{n} \frac{\mathrm{EARN}t}{(1+r)^t} + \sum_{t=n+1}^{10} \frac{\mathrm{EARN}_2 \times (1+\mathrm{gr})^{t-2}}{(1+r)^t} + \frac{\mathrm{EARN}_2 \times (1+gr)^9}{(r-tg)} \times \frac{1}{(1+r)^{10}} - \mathrm{CAPEXADJ} - \mathrm{WCADJ} \tag{9.6}$$

$$r = \mathrm{rf} + \beta \times (\mathrm{rm} - \mathrm{rf}) \tag{9.7}$$

where

VALUE – Corporate market value
PVCF – Present value of the expected operating cash flows
P – Operator representing an American put option
EXIT – Exit value of the corporate assets
SDEV – Standard deviation of the ratio of PVCF over EXIT
EARN t – Analyst forecast of year t after-interest earnings
r – Expected CAPM return
gr – Consensus forecast of 5-year earnings growth
tg – Terminal growth rate of earnings
n – Number of years for which earnings are forecast
CAPEXADJ – Reduction to the present value of analysts' earnings forecasts to adjust for the difference between capital expenditure and depreciation
WCADJ – Reduction to the present value of analysts' earnings forecasts to adjust for growth in working capital
rf – Risk-free rate
β – The corporate beta
(rm – rf) – Risk premium of the stock market over the risk-free rate

Berger et al. (1996) say that this Equation shows that the corporate market value equals the sum of the value of its expected operating cash flows plus the value of the abandonment option in Eq. 9.5, and also that this is strictly appropriate only when the abandonment option involves the choice of selling the entire corporation. 9.6 and 9.7.

This chapter therefore assumes that the project value incorporated with managerial flexibility can be defined as the present value (PV) plus the abandonment option value. There are three steps to estimate the abandonment option value as shown below.

Step 1: Estimation of the project's PV

The PV of a project is obtained by dividing the estimated cash flow by (1 + WACC) shown in Eq. 9.8

$$\mathrm{PV} = \sum_{i=1}^{n} \frac{\mathrm{CF}i}{(1+\mathrm{WACC})^{i}} \tag{9.8}$$

where
PV – Present value of the project
CF – Cash flow
WACC – Weighted average cost of capital
i – Time period

Step 2: Estimation of the project's volatility

The definition of volatility in an option is the standard deviation of the continuously generated return on the underlying asset. Copeland and Antikarov (2001) describe that it is useful to estimate the volatility for the project without options and to use the project without options as the underlying asset for the analysis for such a project. They propose a general method that uses Monte Carlo simulation for estimating project volatility and the standard deviation of this simulated distribution of the project's PV used as the volatility of the project. The assumption of this method is that project volatility is constant. The upper limit, lower limit, average value, and volatility of the project's PV are obtained by Monte Carlo simulation. The Monte Carlo simulation is conducted by using the Crystal Ball spreadsheet application.

Step 3: Estimation of the project's abandonment option value

At first, an event tree is created with a binomial grid model. The binomial model assumes that the benefit from a project follows a multiplicative binomial process over the period. An example of a 2-year event tree is shown in Fig. 9.1.

The multiplicative up factor (u), multiplicative down factor (d) and risk-neutral probability factor (p) can be calculated by using Eqs. 9.9, 9.10 and 9.11.

$$u = e^{\sigma\sqrt{T}} \tag{9.9}$$

$$d = \frac{1}{u} \tag{9.10}$$

$$p = \frac{(1+\mathrm{fr}\times T - d)}{(u-d)} \tag{9.11}$$

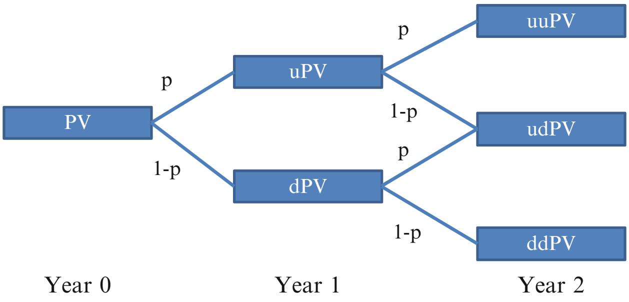


Fig. 9.1 Event tree analysis for 2 years

where
u – Multiplicative up factor
d – Multiplicative down factor
σ – Volatility of the project
T – Time length
p – Risk-neutral probability factor
fr – Risk-free rate

After creating an event tree, a decision tree is built. Each PV at year 2 is compared to an abandonment value which is the profit on the sale of the project. The abandonment option to sell the project is examined by using backward recursion. When constructing the decision tree, managerial flexibility, such as the sale of the project, is reflected in the decision tree. The abandonment option value is identified as the PV at year 0 of the decision tree (expanded PV), minus the PV at year 0 of the event tree.

A specific sample is described as follows. The PV of the underlying asset at year 0 is assumed to be 1,000, the risk-free rate per year is assumed to be 5%, volatility is assumed to be 15%, and there is assumed to be an abandonment option. If PV is less than 900 after 2 years, the project can be sold for 900. Table 9.1 shows the assumptions made in this model and Table 9.2 shows the calculation results related to the up factor, the down factor and the probability factor. The event tree is shown in Fig. 9.2 and the decision tree is shown in Fig. 9.3. The lowest PV at year 2 is less than 900, so the project is sold for 900. The PV at year 1 and PV at year 0 are then calculated; then, the abandonment option value is PV at year 0 of the decision tree (extended PV) minus PV at year 0 of the event tree. So the abandonment option value is 20 (1,020 – 1,000).

2.4 *Total Economic Value*

Total economic value is an indicator which is used in decision-making for capital investments in environmentally friendly projects. The total economic value, including standard NPV, as described in Sect. 2.1, environmental impact reduction value,

Table 9.1 Assumption of this model

Assumption		
Volatility	σ	15%
Time span	Year	1
Risk-free rate	Risk free	5%

Table 9.2 Calculation results

Calculation results		
Up factor	u	116%
Down factor	d	86%
Probability factor	p	63%

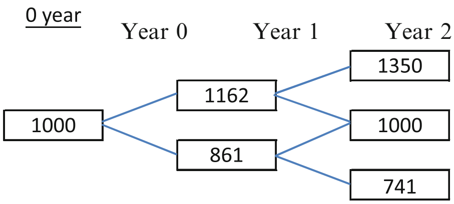


Fig. 9.2 Event Tree Analysis

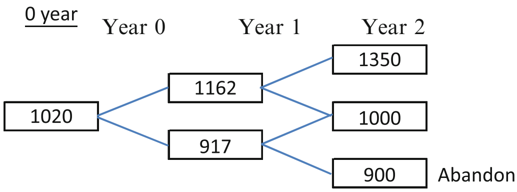


Fig. 9.3 Decision Tree Analysis

as described in Sect. 2.2, and managerial flexibility value, as described in Sect. 2.3, is shown in Eq. 9.12.

$$\begin{aligned}\text{Total Economic Value} = {} & \text{Standard NPV} \\ & + \text{Environmental Impact Reduction Value} \\ & + \text{Managerial Flexibility Value} \\ & \ (\text{abandonment value})\end{aligned} \tag{9.12}$$

The decision flow with total economic value for environmentally friendly projects is shown in Fig. 9.4. Even if a project's standard NPV is negative if the total economic value is positive then a capital investment decision for the environmentally friendly projects can still be made. To make a robust management decision, however, it is important to understand not only the expected average value of the total economic value but also the expected lower level of the total economic value with a 95% confidence interval to protect the company in advance against future uncertainties.

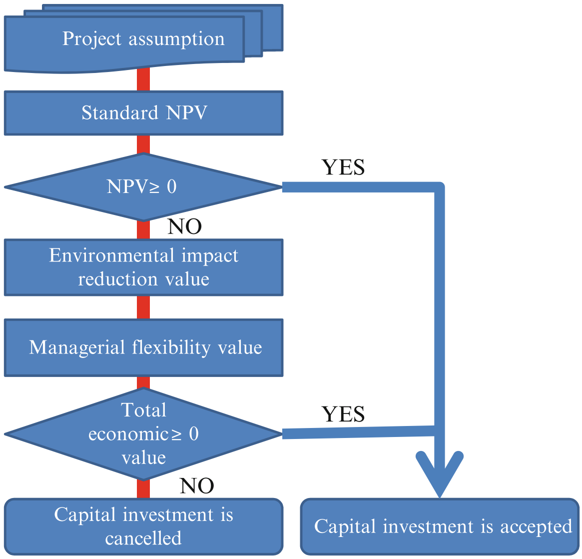


Fig. 9.4 Decision Flow with Total economic value for environmentally friendly projects

3 Empirical Approach

This section explains how the theory which was described in Sect. 2 was applied to an economic value analysis of HEV project by Company A. Assumptions were made on project parameters such as volume, cost, revenue and investment – from 1997 until 2012 – and the going-concern value is assumed after 2012. The NPV, environmental impact reduction value and managerial flexibility value are then estimated and finally, the total economic value is assessed and a sensitivity analysis of NPV and abandonment option value is conducted.

3.1 *Assumption for Case Study*

1. The actual sales volume from 1997 to 2005 is used. It is estimated that the sales volume from 2006 through 2012 is assumed to grow by 20% per annum. The volatility of sales volume is estimated at 15% and the upper limit and the lower limit of a 95% confidence interval in fiscal year 2012 will be 2.24 million and 0.46 million units a year respectively. The sales volume assumption of this case study is shown in Fig. 9.5.
2. The manufacturing cost per unit of gasoline-powered vehicles is estimated as 82% of the revenue per unit, and the revenue of gasoline-powered vehicles is estimated at ¥1,824,000, then the manufacturing cost per unit of gasoline-powered vehicles is estimated at ¥1,496,000.

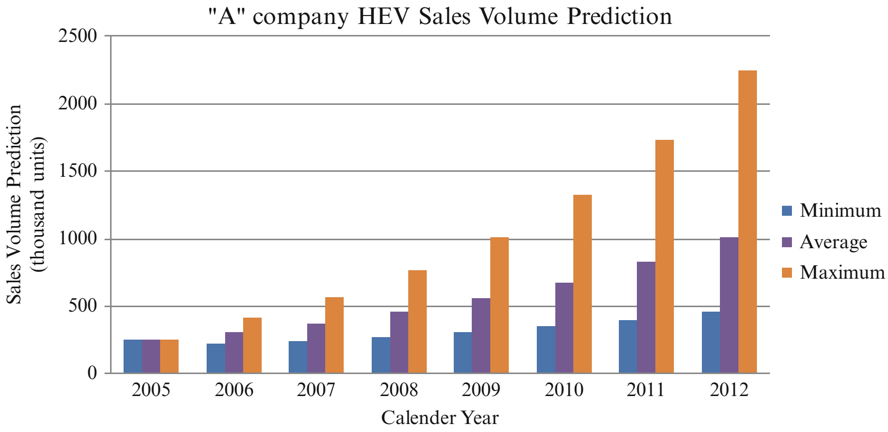


Fig. 9.5 Sales Volume Assumption

3. The additional manufacturing cost per unit of hybrid systems compared to gasoline-powered vehicles is estimated at ¥1,000,000 at the time of the introduction of the first generation HEV in 1997. It is estimated that this cost has decreased by 5% annually from 1997 to 2002 and was ¥500,000 in 2003. Furthermore, it is estimated that the cost has continued to reduce by 5% annually from 2003 to 2008 to become ¥300,000 in 2008.
4. The marginal profit per unit is calculated by deducting manufacturing total costs per unit from revenue per unit, and the annual free cash flow is estimated to be equal to annual net profit (Table 9.3).
5. It is assumed that 50% of environmental research and development investment as stated in the company's environmental and social report is invested in HEV projects. The amount of the research and development expense for environmental investments from 2000 to 2004 has been taken from the environmental and social report for 2005 and the expense in 2005 is estimated to be 10% higher than in 2004. The annual investment from 2006 to 2012 is assumed to stay constant at the same amount as the investment in 2005. The annual investment has been converted to the PV using the risk-free rate and is assumed to occur in the initial year (Table 9.4).
6. Because the discount rate for development investment is less related to market value, the risk-free rate is applied. However, the discount rate for cash flow is related to market value, so the WACC is applied.
7. The risk-free rate is 1.5%. This number is equivalent to the average annual yield of Japanese government long term bonds from 1997 to 2005.
8. The WACC is calculated to be 5.0%. The formula to assess WACC is shown in Eq. 9.13. The basis for this number is the Japanese stock market averaged return (rm) of 8.5%, the company's equity capital to total assets ratio (i.e. its gearing) ($E/(D+E)$) of 60%, β of 0.9, and Japanese corporate tax (T) at a rate of 40% of profits.

Table 9.3 Revenue, cost, profit, tax, free cash flow assumption

Factor	Unit	1997	1998	1999	2000	2001	2002	2003	2004
Sales volume/year	k Units	0	18	15	19	37	41	53	135
Revenue/unit	k Yen	2,310	2,310	2,310	2,310	2,310	2,310	2,310	2,310
Gasoline powered vehicle cost	k Yen	−1,496	−1,496	−1,496	−1,496	−1,496	−1,496	−1,496	−1,496
Additional cost by Hybrid System	k Yen	−1,000	−950	−903	−857	−815	−774	−500	−475
Total cost/unit	k Yen	−2,496	−2,446	−2,399	−2,353	−2,311	−2,270	−1,996	−1,971
Profit/unit	k Yen	−186	−136	−89	−43	−1	40	314	339
Profit/year	Bill. Yen	0	−2	−1	−1	0	2	17	46
Tax/year	Bill. Yen	0	0	0	0	0	1	7	18
Free cash Flow/year	Bill. Yen	0	−2	−1	−1	0	1	10	27

Factor	Unit	2005	2006	2007	2008	2009	2010	2011	2012
Sales volume/year	k Units	250	305	373	456	556	680	830	1,014
Revenue/unit	k Yen	2,310	2,310	2,310	2,310	2,147	2,147	2,147	2,147
Gasoline powered vehicle cost	k Yen	−1,496	−1,496	−1,496	−1,496	−1,496	−1,496	−1,496	−1,496
Additional cost by hybrid system	k Yen	−451	−429	−407	−387	−300	−300	−300	−300
Cost/unit	k Yen	−1,947	−1,925	−1,903	−1,883	−1,796	−1,796	−1,796	−1,796
Profit/unit	k Yen	363	385	407	427	351	351	351	351
Profit/year	Bill. Yen	91	118	152	195	195	238	291	356
Tax/year	Bill. Yen	36	47	61	78	78	95	117	142
Free cash flow/year	Bill. Yen	54	71	91	117	117	143	175	213

Table 9.4 Investment assumption

Factor	Unit	1997	1998	1999	2000	2001	2002	2003	2004
Investment/year	Bill. Yen	−30	−30	−30	−30	−49	−65	−83	−96
Factor	Unit	2005	2006	2007	2008	2009	2010	2011	2012
Investment/year	Bill. Yen	−106	−106	−106	−106	−106	−106	−106	−106

$$\mathrm{WACC} = \mathrm{rf} \times (1 - T)\frac{D}{(D+E)} + (\mathrm{rf} + \beta \times (\mathrm{rm} - \mathrm{rf}))\frac{E}{(D+E)} \tag{9.13}$$

where
β – Beta
(rm – rf) – Market risk premium
T – Tax rate
D – Debt
E – Equity

9. The going-concern value is the assumption that free cash flow of the final year continues for 5 years. It is assumed that the company has an abandonment option to sell this project for ¥750 billion after 2010.
10. It is assumed that HEV can reduce the environmentally harmful substance, CO_2 by 40% compared to gasoline-powered vehicles. The CO_2 emission of gasoline-powered vehicles is assumed to be 150 g/km, so the environmental impact reduction due to HEV is estimated as 60 grams/kilometre.
11. A vehicle's average life time mileage is assumed to be 160,000 km and volatility is assumed to be 10%.

3.2 *Standard NPV*

As described in Sect. 5.2.1 above, there are two steps in identifying the standard NPV of the project: first, to identify the PV and second, to assess the NPV.

Step 1: Calculation of the project's PV

According to the calculation of the PV using Eq. 9.14, the PV is estimated to be 1,019 billion yen.

$$\mathrm{PV} = \sum_{i=1}^{n} \frac{\mathrm{CF}i}{(1+\mathrm{WACC})^i} \tag{9.14}$$

Step 2: Calculation of the project's NPV

According to the calculation of the NPV using Eq. 9.15, it is estimated to be -¥46 billion.

$$NPV = PV - \sum_{i=1}^{n} \frac{Ii}{(1+\mathrm{rf})^i} \tag{9.15}$$

3.3 Environmental Impact Reduction Value

There are three steps in estimating the environmental impact reduction value of a HEV project. Gasoline combustion engines emit environmentally harmful substances, not only CO_2, but also NO_x, carbon monoxide (CO) and hydrocarbon (HC). However, due to three-way catalysts and improvement in continuous combustion systems, the environmental impact of NO_x, CO and HC emissions is actually only small. So, this chapter only focuses on CO_2 and Eq. 9.4 can be simplified to Eq. 9.16:

$$SI = \sum_{CO_2} \mathrm{IF}_{CO_2} \times \mathrm{Inv}_{CO_2} \tag{9.16}$$

where
SI – Social economic impact due to environmentally harmful substances
IF – Social economic impact per amount of weight for CO_2
Inv – Amount of weight of CO_2

To identify the economical impact reduction value, there are three steps. The first is to estimate the social economic impact per amount of weight for CO_2 using LIME. The second is to calculate the total amount of the reduction in the weight of CO_2. The third is to identify the economical impact reduction value.

Step 1: Quotation of environmentally harmful substance weighting values

Itsubo and Inab (2005) state that the weighting value of CO_2 is ¥1,620 per tonne.

Step 2: Calculation of the weight of environmental impact reduction

The lifetime environmentally harmful substance reduction weight per unit can be calculated by multiplying the environmentally harmful substance emission weight per unit mileage of base vehicles by the reduction rate of hybrid vehicles and then multiplying this by the lifetime mileage. The formula is shown in Eq. 9.17.

$$\begin{aligned}&\text{Lifetime environmentally harmful}\\&\quad\text{substance reduction weight per unit}\\&\quad\quad= \text{Base vehicles environmentally harmful substance}\\&\quad\quad\quad\text{emission weight per unit mileage} \times \text{Rate of reduction}\\&\quad\quad\quad\text{by HEV} \times \text{life time mileage}\\&\quad\quad= 150\text{g / km} \times 40\% \times 160{,}000\text{ km} = 9.6\text{ ton / unit}\end{aligned} \tag{9.17}$$

The lifetime environmentally harmful substance reduction of total weight can be calculated by multiplying lifetime environmentally harmful substance reduction weight per unit by the cumulative sales volume. The formula is shown in Eq. 9.18.

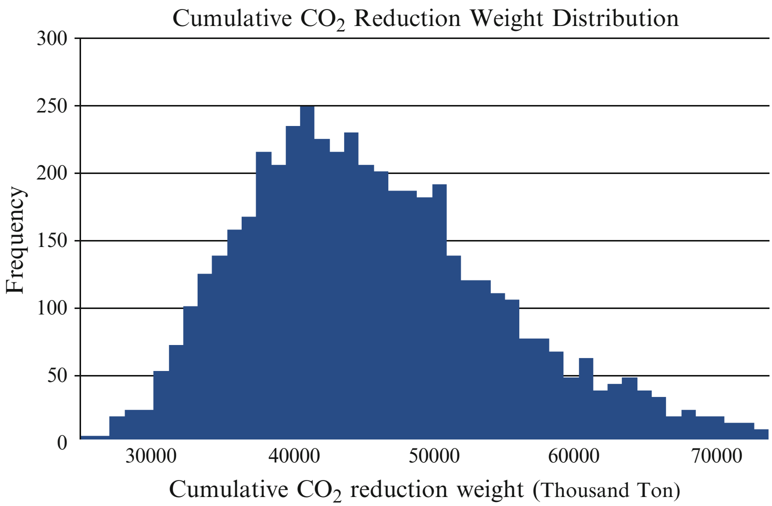
$$\begin{aligned}&\text{Cumulative lifetime environmentally harmful}\\&\quad\text{substance reduction of total weight}\\&\qquad= \text{Lifetime environmentally harmful substance}\\&\qquad\quad\text{reduction weight per unit} \times \text{cumulative sales volume}\\&\qquad= 9.6\,\text{ton / unit} \times 47.8\,\text{million units} = 45.9\,\text{million ton}\end{aligned} \tag{9.18}$$

Using Monte Carlo simulation, the standard deviation is estimated to be 9.7 million tons.

The upper and lower limits of a 95% confidence interval are 74,775 kilotons and 26,542 kilotons, respectively. This simulation was iterated 5,000 times (Fig. 9.6).

Step 3: Calculation of the environmental impact reduction value

The economic value of environmentally harmful substance reduction can be calculated by multiplying the weighting value obtained in Step 1 by the cumulative



Number of iteration	5000	Times
Standard deviation	9677	KTon
Average	44400	K ton
Maximum at 95% confidence	74775	K ton
Minimum at 95% confidence	26542	K ton

Fig. 9.6 Cumulative CO_2 reduction weight simulation result (k tons)

lifetime environmentally harmful substance reduction of total weight obtained in Step 2. The formula is shown in Eq. 9.19.

$$\begin{aligned}&\text{Environmental impact reduction value}\\&\quad = \text{Weighting value} \times \text{Cumulative lifetime environmentally}\\&\qquad \text{harmful substance reduction of total weight}\\&\quad = ¥1{,}620/\text{ton} \times 45.9 \text{ million ton} = ¥74 \text{ billion}\end{aligned} \tag{9.19}$$

The upper and lower limits of a 95% confidence interval are estimated to be ¥121 billion and ¥43 billion, respectively.

3.4 Managerial Flexibility Value

Step1: Estimation of the project's PV

The PV is estimated by Eq. 9.20.

$$PV = \sum_{i=1}^{n} \frac{\text{CF}i}{(1+\text{WACC})^i} \tag{9.20}$$

Step 2: Estimation of the project's volatility of the PV

The volatility of the PV was calculated using the Monte Carlo simulation which was run 5,000 times. The result was an estimate that the average value of the PV is ¥1,029 billion. The upper and lower limits of a 95% confidence interval are ¥2,571 million and -¥410 million, respectively, with the standard deviation for 12 years is ¥635 billion. Hence, the annual volatility is estimated to be 20%. The formula is shown in Eq. 9.21 and the distribution of PV is shown in Fig. 9.7.

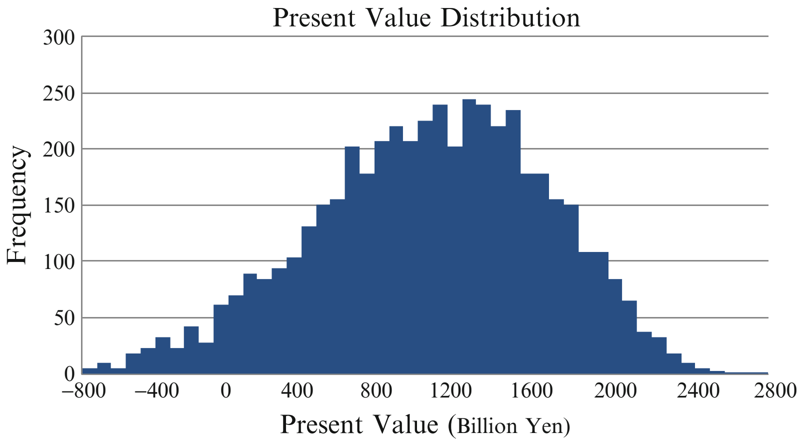
$$\text{Volatility/Year} = \sigma_T / \sqrt{T} = 635/\sqrt{12} = 20\% \tag{9.21}$$

Step 3: Calculation of the project's abandonment option value

First, an event tree was created using a binomial grid model. Taking ¥1,019 billion of the net value for 1996 as the starting point, the event tree is developed from left to right. As the interval period of the event tree analysis is 6 months, there are 30 steps from 1996 to 2012.

The annual volatility of the PV is 20%. According to Eqs. 9.22 and 9.23, the multiplicative up factor is 115%, the multiplicative down factor is 87%, and the risk-neutral probability factor is 49%. The event tree analysis is shown in Fig. 9.8. This figure illustrates the value from every second step of the 30 step analysis.

$$u = e^{\sigma\sqrt{T}} = e^{0.2\sqrt{0.5}} = 115\%, \quad d = \frac{1}{u} = 87\% \tag{9.22}$$



Number of iteration	5000	Times
Standard deviation	635	Bil. Yen
Average	1029	Bil. Yen
Maximum at 95% confidence	2571	Bil. Yen
Minimum at 95% confidence	–410	Bil. Yen

Fig. 9.7 PV distribution

$$p = \frac{(1 + \mathrm{fr} \times T - d)}{(u - d)} = \frac{(1 + 0.015 \times 0.5 - 0.87)}{(1.15 - 0.87)} = 49\% \quad (9.23)$$

After creating the event tree, a decision tree was built. It was assumed that the project can be sold for ¥750 billion after 2010. A decision tree is extended from the end point on the right to the left. The expanded PV which is delivered by the decision tree becomes ¥1,085 billion and the abandonment option value is estimated as the expanded PV minus PV. From Eq. 9.14 the PV is ¥1,019 billion, so the abandonment value is ¥66 billion. The decision tree is shown in Fig. 9.9.

3.5 *Total Economic Value*

Total economic value is defined as the NPV plus the environmental impact reduction value plus the managerial flexibility value (abandonment option value).

Accordingly, the total economic value is ¥94 billion.

Fig. 9.10 shows the transition from the NPV to the total economic value.

If management ignores the effects of the environmental impact reduction value and the abandonment option value, and evaluates only the standard NPV, it would not decide in favor of investing in this environmentally friendly project. However,

1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
															58914
														44400	44400
													33462	33462	33462
												25218	25218	25218	25218
											19005	19005	19005	19005	19005
										14323	14323	14323	14323	14323	14323
									10794	10794	10794	10794	10794	10794	10794
								8135	8135	8135	8135	8135	8135	8135	8135
							6131	6131	6131	6131	6131	6131	6131	6131	6131
						4620	4620	4620	4620	4620	4620	4620	4620	4620	4620
					3482	3482	3482	3482	3482	3482	3482	3482	3482	3482	3482
				2624	2624	2624	2624	2624	2624	2624	2624	2624	2624	2624	2624
			1978	1978	1978	1978	1978	1978	1978	1978	1978	1978	1978	1978	1978
		1491	1491	1491	1491	1491	1491	1491	1491	1491	1491	1491	1491	1491	1491
1019	1123	1123	1123	1123	1123	1123	1123	1123	1123	1123	1123	1123	1123	1123	1123
		847	847	847	847	847	847	847	847	847	847	847	847	847	847
			638	638	638	638	638	638	638	638	638	638	638	638	638
				481	481	481	481	481	481	481	481	481	481	481	481
					362	362	362	362	362	362	362	362	362	362	362
						273	273	273	273	273	273	273	273	273	273
							206	206	206	206	206	206	206	206	206
								155	155	155	155	155	155	155	155
									117	117	117	117	117	117	117
										88	88	88	88	88	88
											66	66	66	66	66
												50	50	50	50
													38	38	38
														28	28
															21

Fig. 9.8 Event tree analysis (unit; billion yen)

if they consider these factors, then the project is shown to be value-creating and it may decide to support it.

3.6 Summary

The new decision-making method for environmental investment has been applied to the HEV project of company A. As a result, the NPV of the project is – ¥46 billion, i.e. it has been negatively assessed. However, when the environmental impact reduction value and the abandonment option value are factored in, the total economic value is ¥94 billion so that it will be positively assessed. This indicates

1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
															58914
														44400	44400
													33462	33462	33462
												25218	25218	25218	25218
											19005	19005	19005	19005	19005
										14323	14323	14323	14323	14323	14323
									10794	10794	10794	10794	10794	10794	10794
								8135	8135	8135	8135	8135	8135	8135	8135
							6131	6131	6131	6131	6131	6131	6131	6131	6131
						4621	4621	4620	4620	4620	4620	4620	4620	4620	4620
					3483	3483	3482	3482	3482	3482	3482	3482	3482	3482	3482
				2629	2628	2627	2626	2625	2625	2624	2624	2624	2624	2624	2624
			1994	1991	1989	1987	1984	1982	1981	1979	1978	1978	1978	1978	1978
		1528	1525	1522	1518	1515	1511	1507	1503	1499	1495	1492	1491	1491	1491
1085	1196	1193	1190	1186	1182	1177	1172	1167	1161	1154	1147	1139	1131	1123	1123
		963	960	957	954	950	945	940	933	926	917	906	893	875	847
			813	812	810	809	807	804	800	796	791	784	776	765	750
				728	730	731	733	735	736	738	740	743	745	750	750
					690	695	701	707	713	720	728	738	750	750	750
						681	689	698	707	717	728	739	750	750	750
							686	696	706	717	728	739	750	750	750
								696	706	717	728	739	750	750	750
									706	717	728	739	750	750	750
										717	728	739	750	750	750
											728	739	750	750	750
												738	750	750	750
													750	750	750
														750	750
															750

Fig. 9.9 Decision tree analysis (unit; billion yen)

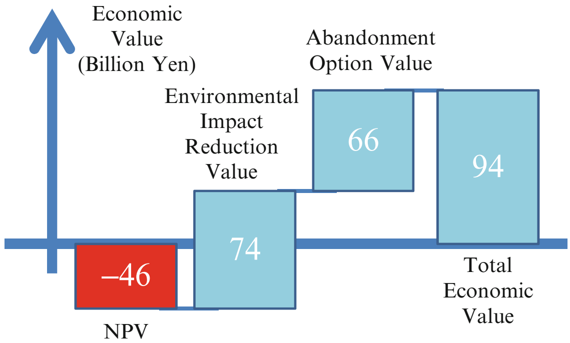


Fig. 9.10 Total Economic Value

that even if a decision for investment cannot be made for a project using existing methods, a judgment that it is appropriate to make an investment in a project can be made using the new method. This is the result of reflecting the corporate value creation from environmental impact reduction, and managerial decisions in response to project uncertainties.

On the other hand, the lower limit of the 95% confidence interval is negative even after the economic value of the environmental impact reduction value and the abandonment option value are incorporated. This can be attributed to the significant volatility of the PV.

Regarding this issue, company management should focus on internal factors that they can control rather than external factors, continue to improve the PV, and also make every effort to reduce capital investment – cost reduction, investment reduction, acceleration of technology development, marketing activities, etc. – and to improve the lower limit. By doing so new options may be created and the economic value of the environmentally harmful substance reduction may increase.

4 Sensitivity Analysis

By using a simulation model, a sensitivity analysis can be conducted on the NPV and abandonment option value (AOV) for each influencing factor in the abandonment option. The influencing factors covered in this sensitivity analysis were volatility, abandonment value, WACC, and risk-free rate.

4.1 Sensitivity Analysis of Volatility

As indicated in Fig. 9.11, AOV increases linearly as volatility increases. NPV is based on the assumption that the situation includes no uncertainties and is therefore not affected by volatility.

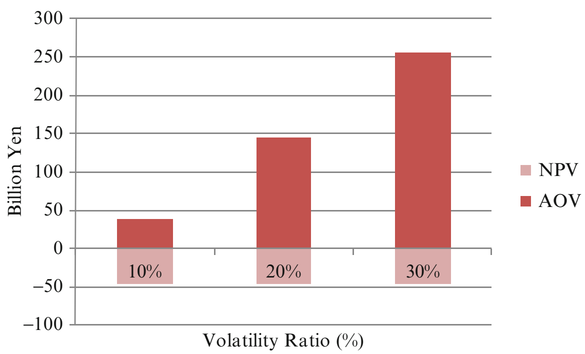


Fig. 9.11 Sensitivity of Volatility

4.2 Sensitivity Analysis of Abandonment Value

As indicated in Fig. 9.12, AOV increases linearly as abandonment value increases. NPV is not affected by abandonment value.

4.3 Sensitivity analysis of WACC

As shown in Fig. 9.13, when WACC increases AOV increases. This is a result of the fact that the PV at the end point decreases due to the impact of WACC and increases its effect on the abandonment value. Furthermore, when WACC increases, PV decreases and therefore the NPV significantly decreases.

4.4 Sensitivity Analysis of Risk-Free Rate

As shown in Fig. 9.14, when the risk-free rate increases AOV decreases and NPV increases. The PV is independent from the risk-free rate, but the PV of the capital investment is significantly affected by it so that the NPV is therefore very sensitive to it.

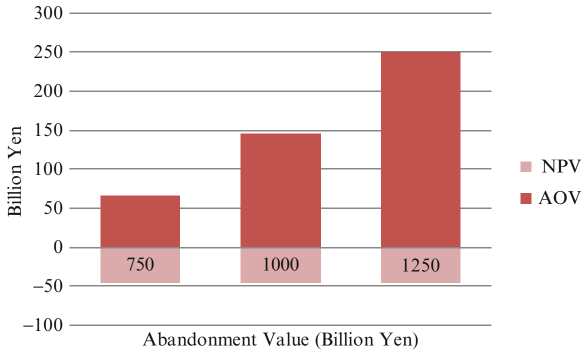


Fig. 9.12 Sensitivity of Abandonment Value

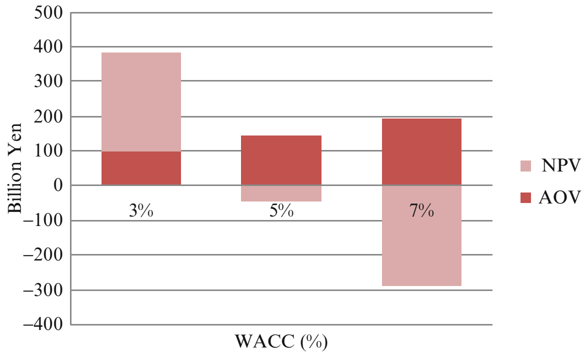


Fig. 9.13 Sensitivity of WACC

Fig. 9.14 Sensitivity of Risk free rate

4.5 Sensitivity Analysis Summary

Sensitivity analysis was conducted on the major factors that affect NPV and AOV. The assumptions of higher volatility, higher abandonment value, higher WACC and lower risk-free rate result in a higher AOV. Also, the assumptions of lower WACC and higher risk-free rate result in a higher NPV.

5 Conclusion and Future Challenges

5.1 Conclusion

Innovative environmentally friendly projects are often accompanied by drastic increases in development investment and manufacturing costs, and by huge uncertainties, not only technical but also business. Consequently, they are often accompanied by deterioration in cash flow in the short-term due to the huge investment which is required, and are also not guaranteed a return even in the medium and long term time frames.

The purpose of this chapter is to establish a decision-making method for capital investment in environmentally friendly projects. This method enables management decisions to be made appropriately under highly volatile conditions while promoting good corporate environmental behaviour. The best method of controlling management environmental behaviour may be through financial assessment, including the value of environmental elements through corporate environmental behaviour and the value of management's decision flexibility. Also, this chapter contributes to expand decision-making methods for environmental capital investment in environmental accounting.

There are two challenges in establishing a decision-making method for environmentally friendly projects. The first is corporate value creation from environmental impact reduction. Social environmental value creation, that is, environmental impact reduction, from environmental investment can be converted into internal corporate value creation. The economic value of the environmental impact reduction is assessed by LIME. The second is incorporating management decision flexibility into the appraisal of environmental investment.

Then, the total economic value of the environmentally friendly projects includes the standard NPV plus environmental impact reduction value plus managerial flexibility value.

The new environmental investment decision-making method was then applied to the HEV project at Company A to verify its effectiveness. As a result, it indicates that a capital investment project that is judged to be unattractive from an economic perspective when evaluated using existing methods can be shown to be economically attractive when this new decision method is applied. This method is therefore considered likely to contribute to the promotion of innovative economically friendly projects.

5.2 Limitations

This chapter focuses on innovative technology development projects that are characterised by significant uncertainties, a long implementation period and nearly zero or negative of NPV. In addition, it requires that cash flow and the uncertainties for the applicable period can be quantified and that managerial flexibility can be applied to a decision tree so that applicable real options can be identified. There are limitations to the extent to which this new decision method can be applied to projects that do not meet these preconditions.

5.3 Future Challenges

This chapter is based on the assumption that there is no competition. However, under actual market conditions, competition usually exists and the impact of competitors can be significant. Fairchild (2008) has developed a game-theoretic model that analyses corporate incentives to engage voluntarily in non-productive environmental investment and demonstrates that competing corporate incentives to environmental investment are driven by the extent of public “green” awareness and the level of investment costs. The future challenge is how the competition-effect and strategic interaction can be incorporated into a practical investment appraisal technique.

References

Auger P, Burke P, Devinney TM and Louviere JJ (2003) What will consumers pay for social product features? *Journal of Business Ethics* 42.3 281–304

Berger PG, Ofek E and Swary I (1996) Investor valuation of the abandonment option *Journal of Financial Economics* 42.2 257–287

Chen YS, Shyh-Bao L and Wen CT (2006) The influence of Green innovation performance on corporate advantage in Taiwan *Journal of Business Ethics* 67.4 331–339

Copeland T and Antikarov U (2001) *Real Options: A Practitioner's Guide* New York, Texere Llc.

Fairchild R (2008) The manufacturing sector's environmental motives: a Game-theoretic analysis *Journal of Business Ethics* 79.3 333–344

Itsubo T and Inab A (2005) *Life Cycle Environmental Impact Assessment Methodology* Japan, Japan Environmental Management Association for Industry

Kokubu K (1999) *Social and Environmental Accounting* Tokyo, Chuokeizai-Sha Inc.

Kokubu K (2000) *Environmental Accounting* (Revised and Enlarged Edition) Tokyo, Saiensu Sha Co. Ltd.

Lyon T and Maxwell J (1999) Voluntary approaches to environmental regulation: a survey in Franzini M and Nicita A *Environmental Economics: Past, Present and Future* Farnham, Ashgate Publishing

Machlachlan J and Gardner J (2004) A comparison of socially responsible and conventional investors *Journal of Business Ethics* 25.1 11–25

Ministry of Economy, Trade and Industry (2002) *Environmental Management Accounting Workbook* Tokyo, Ministry of Economy, Trade and Industry Japan

Mun J (2003) *Practical Real Option* Trans. Tokyo, Kozo Keikaku Engeneering Inc.

Myers SC and Majd S (1990) Abandonment value and project life *Advances in Futures and Options Research* 4 1–12

Schaltegger S (2008) Sustainability and accounting: the question for management Managing Business Cases for Sustainability *7th Proceedings of the Australasian Conference for Social and Environmental Accounting Research (A-CSEAR)* Adelaide, CAGS 25–33

Smit HTJ and Trigeorgis L (2006) Real option and games: competition, alliances and other applications of valuation and strategy *Review of Financial Economics* 15.2 95–112

Trigeorgis L (2001) *Real Options* Trans. Kawaguchi Y, Maekawa S, Takezawa N and Yamaguchi T, Tokyo, The Economist

United States EPA (1992) *Total Cost Assessment: Accelerating Industrial Pollution Prevention through Innovative Project Financial Analysis* Washington DC, EPA

Williamson D, Lynch-Wood G and Ramsay J (2006) Drivers of environmental behaviour in manufacturing SMEs and the implications for CSR *Journal of Business Ethics* 67.3 317–330

Chapter 10
Carbon Accounting in Greek Companies Participating in the European Union's Emissions Trading Scheme: Current Practice and Projected Financial Implications

Benjamin Karatzoglou and Ourania Karatzoglou

Abstract Lack of a solid, uniform, efficient, and objective accounting background to record the economic impact of the tradable permits "grandfathered" to polluting companies misleads the users of corporate financial statements and hinders comparisons of performance. Further, it conceals the financial threat that an imminent need to purchase permits imposes on the profitability and competitiveness of companies participating in emissions trading schemes. The objectives were to investigate the way in which Greek companies record and treat transactions relating to carbon emissions allowances from an accounting perspective; and to predict the impact on corporate financial performance and economic prospects of future purchases of allowances. Data were collected by means of both primary research via questionnaires and telephone contacts and secondary research through the audited financial statements published by the sample corporations. Findings from research conducted in Greece in 2008 are presented and discussed. The working hypothesis was that in the following year, 2009, emissions trading scheme participants would have to purchase the currently free permits at the average stock exchange price established by market mechanisms. The role of variables, such as corporate size, sales, profitability, headcount, and asset base, was investigated to explain the choices and measure the significance of the impact. The results provide an insight to the perceptions of the companies, criteria of choice and economic prospects.

Keywords European Union Emissions Trading Scheme • Greece • Tradable permits • Allowances • Ratios

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1 Overview

1.1 The European Union's Emissions Trading Scheme (EU-ETS)

Climate change is viewed as a critical global issue. To meet the obligation to reduce its aggregate annual average emissions of greenhouse gases (GHG) for 2008–2012 by 8% under the Kyoto Protocol's baseline level, the European Union (EU) proposed a GHG cap-and-trade emissions trading scheme (ETS) in 2001 and activated it in 2004. The EU-ETS covers more than 11,400 energy-intensive facilities across EU member countries, which emit about 45% of the EU's carbon dioxide (CO_2) emissions.

The first three-year trial trading period (2005–2007) has been completed and allows a close scrutiny to support future adjustments and suggestions to make the second trading period (2008–2012) run more effectively. The first phase pinpointed inadequate and inaccurate emission data and established much of the critical infrastructure necessary for a functional emissions market, including monitoring, registries, and inventories. A key result of the first phase was its effect on corporate behaviour. A European Commission (EC) survey of stakeholders indicated that many participants incorporated the value of allowances for carbon emissions in making decisions, particularly in the electric utility sector with 70% of firms stating that they were pricing the value of allowances into their daily operations and 87% into their future marginal pricing decisions (European Commission Directorate General for Environment 2005). However, several issues that arose during phase one – such as permit auctions, accounting treatment of permits, design and use of benchmarks, shutdown credits, and new entrant reserves – remain contentious as the ETS implements phase two, raising new issues to which the EU will have to respond before proceeding with phase three proposed for 2013.

On the 23rd of January, 2008, the EC submitted the Proposal for a Directive (European Commission 2008) to improve and extend the Community's GHG emission allowance trading system. According to this proposal, the ETS should expand to include additional sectors (petrochemicals, ammonia and aluminium) and to eliminate National Allocation Plans (NAPs) and have them replaced by EU-wide, harmonised rules with respect to permit availability and allocations. The EC has prescribed auctioning as the main tool to pursue effective ETS implementation in the future. Like most of its EU counterparts, the Greek government was unwilling or unable to move away from free allocation. Neither did it employ any auctions during the first two phases, nor did it combine an auction with a reserve price to encourage development of new technologies, intimidated by the impact that such initiatives might have on the low competitiveness of domestic industry. Yet, starting in 2013 with the power sector, the EU aims to auction at least two-thirds of the available allowances. The introduction of auctioning will differ in each sector and is envisioned to begin with 80% of a sector's allocation provided free in 2013, reducing to zero by 2020. Efforts to expand sectors, apply auctioning, and charge the allowances, met with strong opposition from industry groups but attracted support from environmental groups and economists.

However, allocating allowances is essentially allocating money with the marketplace determining the exchange rate (Parker 2008). In the absence of an accounting standard, the free allocation scheme used by the ETS has resulted in "windfall profits" for allowance recipients, either States or individual companies (Sijm et al. 2006). An array of complicated tools and practices, developed to manage permit exchanges and GHG leakages, have been suggested. For instance, use of the clean development mechanism (CDM) and joint implementation (JI) credits will significantly increase the flexibility that facilities have to meet their reduction targets and reduce both the EU's Kyoto compliance costs and allowance price volatility. As a further defence against price volatility, the European Emissions Exchanges are creating financial instruments, such as futures contracts and options, to permit entities to hedge against price changes. Data suggest that a new €25bn allowance market (PointCarbon 2007) is developing and company support, accounting standardisation, and enhanced regulatory and oversight authority are urgently needed to achieve stability and the optimal use of the instruments offered. Moreover, by bringing the value of CO_2 emissions on to the balance sheet, the EU-ETS established a connection between carbon emissions and corporate value with an accompanying need to communicate relevant corporate performances clearly and unambiguously to stakeholders.

The lack of a solid institutional and organisational framework, coupled with the shortage of auditing and verification procedures from independent external parties, has resulted in an arbitrary recording of the tradable emission allowances by the corporate accounting departments, since many relevant questions remain unanswered (Schaltegger et al. 2003). Deloitte and Touche LLP contends that the development of carbon markets worldwide has created a host of challenges for companies – and the least understood among these challenges is the accounting treatment. Europe has not reached consensus yet on how to account for emission allowances. Moreover, as carbon markets evolve and incorporate new elements, additional accounting challenges will emerge (Deloitte Center for Energy Solutions 2009). Schreuder (2009) calls into question the current emissions accounting practices and calls for a restructure and coordination of practices at a global level to make clear the role of the multinational companies. The International Financial Reporting Interpretations Committee (IFRIC) initially took the task to suggest a standard that would address the common accounting questions asked by corporations and issued *IFRIC 3: Emission Rights* in 2004 (IFRIC 2004). Considerable pressure from the business community, lobbyists and European politicians led to its withdrawal by the International Accounting Standards Board within a year.[1]

The notable absence of accounting guidance and market consensus led to different accounting results, as companies individually developed accounting policies in the absence of explicit and authoritative literature. Uniformity was undermined, as was validity of the financial disclosure offered by corporate reports. Recognition

[1] http://www.iasplus.com/interps/ifric003.htm#withdraw

and measurement issues were raised involving inter alia: recording of allowances as intangible assets or inventory; recording of allowances as obligations; changes in the value of allowances owned by the company; forward emission contracts; auctioning processes and penalties incurred if companies failed to meet their obligations. Being left to decide which method was acceptable and appropriate, companies either completely ignored the financial impact of the "grandfathered" allowances (the official EU term for allowances freely offered) or improvised in a way that would improve forthcoming profit-and-loss and cash-flow statements, disregarding the long-term financial implications of the selected practice. A joint survey by PricewaterhouseCoopers (PwC) and International Emissions Trading Association (IETA) (PwC and IETA 2007), identifies as many as 15 distinct approaches applied by the responding EU-ETS participating companies, which the researchers reduced to 6 main approaches after ignoring secondary differences in classification. Unfortunately, no Greek company participated in the survey. However, misallocating or inaccurately costing emission allowances concerns, directly or indirectly, all industries and consumers, since it is expected to have an increasingly significant impact on the prices of electricity, gas, and other emissions-related commodities and activities (Daskalakis et al. 2009). This chapter demonstrates the importance of clear accounting policies and suggests an analysis of the EU-ETS financial implications in the presence of an emerging international carbon market and the launch of EU consultations to review and improve the current scheme for the post-2012 period.

1.2 Implementation in Greece

For the first phase of the EU-ETS implementation, Greece was allocated 223,267 kilotons of CO_2-equivalent emissions all of which were granted free to the 140 companies falling within the NAP provisions (KAPE CRES 2005). The annual allowances and verified emissions per sector are presented in Table 10.1.

In 2005, the verified emissions of the Greek companies exceeded the national annual allocated amount of 71,135,034 tons by 240,137 tons (or 0.3% of the total). A surplus of 1,114,947 tons (1.6% of the total amount) was recorded for the second year and then a deficit equal to 1,492,166 tons or 2.1% of the total for the year 2007. The role of each sector in the scheme differs strongly, with the power generation sector, and in particular the Public Power Corporation (PPC), being responsible for the overwhelming majority of the total emissions.

According to the data provided by the European Environment Agency and Eurostat, Greece ranks 11th among the 27 countries of the enlarged EU in terms of megatons (Mt) of CO_2 equivalent emissions and 13th in terms of the discounted per capita emissions. The ranking indicates the significance of evidence from the Greek companies at EU level as well as their potential for further improvements.

No research has been found for Greece, examining the intercompany allowance flows at a national/industry level, the accounting practices applied, or the impact

Table 10.1 Annual allowances and verified emissions for the first EU-ETS phase in Greece (kilotons of CO_2)

Sectors	Number of installations	Annual allowances	Verified emissions 2005	Verified emissions 2006	Verified emissions 2007
Combustion (Power generation – PPC)	29	51,962,269	52,596,568	51,049,725	53,768,231
Combustion (Power generation – other)	1	102,535	38,245	10,541	111,501
Coke ovens	11	1,155,235	1,135,096	1,046,275	941,043
Refineries	4	3,432,002	3,637,235	4,303,109	4,368,268
Metals – roasting and sintering	1	807,292	868,478	827,442	892,482
Iron and steel	5	797,543	385,807	395,983	411,003
Cement	8	11,071,626	10,973,511	10,744,762	10,458,737
Lime	16	651,098	592,789	582,187	647,093
Glass	3	87,351	67,833	47,605	50,795
Bricks and ceramics	42	778,936	786,086	719,909	687,853
Pulp and paper	15	181,728	186,104	185,130	182,775
Total	**135**	**71,027,615**	**71,267,752**	**69,912,668**	**72,519,781**

Source: CITL (2008)

that the imminent purchase of allowances will have on the financial statements and ratios of the companies participating in the EU-ETS, and the role of certain variables on the severity of this impact.

In this chapter, the findings of research conducted in Greece in 2008 are presented and discussed. The working hypothesis was that in the following year (2009), ETS participants would have to purchase the permits at the average stock-exchange price established by market mechanisms. In the next section, the research methodology is presented. The chapter then proceeds with the presentation of findings in section three and discussion and suggestions for the future in section four. Finally, section five provides a summary and draws conclusions from the study.

2 Methodology

The research investigated the way in which sample companies recorded and treated their allowances, transactions and the impact of the assumed-need to pay for the permits on their financial performance and economic prospects. The role of variables, such as corporate size, sales, profitability, employee numbers, and asset base, was investigated to measure the significance of the impact on the economy and employment. Appropriate ratios were designed to combine physical with financial performance data. The ratio interpretation would gain much if it occurred in comparison with past performance, predetermined standards, or benchmarks. Unfortunately, data availability is still limited, predetermined standards are non-existent, and benchmarking is absent because of source heterogeneity and information shortages (Ellerman et al. 2007). The research was conducted as an empirical study to explore two pending issues of worldwide interest: the financial repercussions of the EU-ETS implementation and the criteria of choice of accounting practices in the light of nonexistent pertinent standards. Relevant concerns are commonplace, particularly among small-to-medium sized enterprises (SMEs) participating in the scheme and this is manifested in a number of EU papers suggesting that the threshold for participation to the scheme be increased and alternative measures for small emitters taken to help reduce overall GHG-related costs (Schleich and Benz 2004, European Commission Directorate General for Environment and Ecofys 2007).

In the first phase of the Greek NAP, 142 installations were registered. Six never submitted a verified report because of closure and one submitted a zero-content report. The remaining 135 active installations were scattered over Greece.

In order to investigate the accounting treatment of allowances transactions by the eligible Greek companies, the authors developed and pilot-tested a questionnaire. Companies were asked to submit data on the number of allowances granted and consumed by each installation, suggested justification for the variations, the accounting treatment of the allowances, and corporate reactions to and expectations from the implementation of the scheme in financial terms. The questionnaire was sent via email to the 122 major Greek NAP participating installations, each of them producing over 5,000 tons of CO_2 annually, constituting 90.4% of the registered installations, yet responsible for 99.9% of the permits allotted to Greece. In the case of NAPs, installations rather than companies have been set as the unit basis for allocation and measurement reasons (FEE 2005). The questionnaire contained eighteen questions: one open-ended, twelve dichotomous and five multiple choice. Since in many cases two or more installations belonged to the same company, only 80 letters were required to be distributed to cover the 122 installations. A reminder was sent to the non-responding companies.

In total 28 firms representing 69 installations, 89% of national emissions responded (response rate of 56.5%). Throughout the collection process it became evident that in many cases, there was either a managerial void as to whom should be contacted, or the person appointed was unfamiliar with the financial and accounting aspects of the allowances and therefore was inappropriate as a respondent. In general, the people contacted were reluctant to provide information, invoking a variety of excuses including a lack of authority, shortage of time, and confidentiality issues.

The second objective, namely that of predicting the impact of future allowance purchases on corporate financial performance, was addressed in the following way. Secondary data involving the number of the allotted permits and the verified emissions per company were collected from the official Community Independent Transaction Log (CITL 2008).

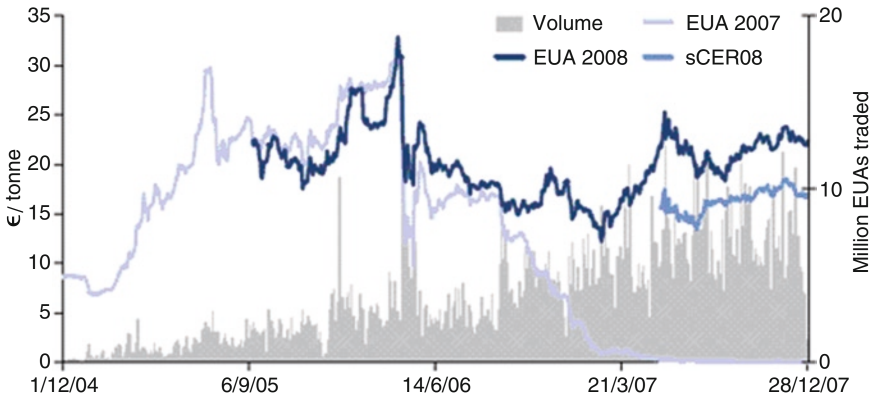

Fig. 10.1 Price and traded volume of the EUAs for the 2004–2007 period (Source: PointCarbon 2008)

As shown in Table 10.1, PPC dominates the Greek emissions profile and consequently the Greek permits market, dwarfing the role of other participants. With 29 installations possessing 73.1% of Greek NAP allowances, the sample, just like the Greek market, is dominated by the trends set and decisions made by that particular corporation, making statistical analysis pointless.

To calculate the economic impact of the forthcoming auctioning of allowances, the sample of companies that submitted completed questionnaires are used, with the exception of two micro-enterprises which do not produce audited financial reports. The working hypothesis is that the average cost per European Union Allowance (EUA) can be established by market mechanisms and be determined by dividing the total annual transactions value in the official EU carbon markets by the number of the allowances exchanged measured in megatons of CO_2 (PointCarbon 2007). The formula gave a historic average cost of €19.93 per EUA for the year 2005, €17.83 for 2006 and €17.50 for 2007. The computed rates strongly follow the pattern of the EU-ETS traded volumes and value/ton for the same period as presented in Fig. 10.1.

3 Findings

3.1 Number of Responses, Types of Companies and Industries

The major findings from the analysis of the questionnaires returned are as follows:

- Thirteen companies (46.4%), representing 50 installations (72.5%) admitted that the number of allowances allocated by the NAP was fair and adequate for their needs. The main objection of disgruntled companies related to the allowances should be allocated based on maximum rather than average capacity for the base year.

- Only 5 of the 69 installations (5 of the 28 companies) emitted gas quantities equal to the allocated amounts. Twelve companies recorded a surplus and 11 a deficit.
- Nine of the companies (39 installations) with a deficit had to buy extra allowances in the free market, while the rest "borrowed" allowances from companies with a surplus and returned them from their allotment of the next year. Six installations purchased additional permits from other Greek companies, one installation directly from a foreign company and the remaining 32 from international allowance brokers, mostly from NATSOURCE and ICECAP Allowance Exchanges. No company chose to pay the fine for exceeding its share, since for the first EU-ETS phase the fine had been established at €40/ton while the market price of allowances was consistently lower.
- Among the 18 companies which recorded a surplus:
  - Four companies, managing 13.0% of the installations, suggested the use of innovative and more efficient production methods as a possible explanation for their surplus, revealing the poor efficiency of the scheme.
  - Another 12 companies, occupying 24.6% of the installations, suggested a reduction of their normal operating capacity as a possible explanation.
  - Only two companies admitted that they received an exaggerated number of allowances considering their real needs.
- Twelve of the companies with a surplus (42.8% of the responses or 27.5% of the installations) applied intra-period banking, carrying forward the unused permits in the next accounting period. Another five companies (17.8% of the sample or 14.5% of the installations) chose to sell their surplus allowances in the international market and improve their recorded financial performance.

3.2 Types of Accounting Treatments Found

In relation to the accounting treatment of the allowances, six companies (21.4% of the sample, 49.3% of the installations) debited the acquisition of the permits in their intangible assets accounts while crediting government grants. Seven companies (25% of the companies or 18.8% of the installations) monitored their CO_2 emissions with provisions accounts. No company fully applied the IFRIC3 approach while the majority (53.6% of the companies or 31.9% of the installations) did not make any accounting entry, recognising the allowances granted at nil value. These findings are close to those produced by the PwC-IETA (2007) survey. In that case, 65% of the respondents recognised the allowances granted within intangible fixed assets, 5% of the respondents applied the IFRIC3 approach, while 60% recognised the granted allowances at nil value.

The companies which purchased additional allowances debited the purchase cost in their operating expenses in four cases (46.4% of the sample installations), in their extraordinary expenses in another four cases (46.4%), and in one case, capitalised the purchase cost to amortise it in the next 5 years. With the exception of the second group, it becomes evident that companies re-externalise their environmental cost by treating it as part of their operating expenses and pricing their products accordingly. The PwC and IETA (2007) survey found that allowance purchase costs were expended in the year the permits are acquired in 86% of cases and capitalised to be amortised in 14%. Fifty-eight percent of respondents recognised allowances purchased within intangible fixed assets, with the balance recognising them somewhere within inventory (11%) or "elsewhere" on the balance sheet.

The companies which sold their surplus allowances credited the income received in their "Subsidies and Other Operating Revenues" account in nine cases (or 15 installations), or chose to make no entry in eight cases (or 13 installations) thus recording an untaxed profit. This choice not to make an entry, coupled with the fact that no Greek company proceeded with a year-end revaluation of its allowances according to fair market value, distorts the accounting figures and provides ample space for windfall profits. The PwC and IETA (2007) survey found that 79% of respondents do not revalue the allowances subsequent to initial receipt or purchase. Among the remaining 21%, all recognised the corresponding entry of the revaluation directly in the income statement rather than through reserves and this applies for those companies that recognise their allowances as intangibles, in which case recognition of a profit or loss should be precluded according to International Accounting Standard 38. Where the impact of the allowances is material to the organisation – as is the PPC case in Greece – the application of such different policies leads to serious distortion of the accounting figures found in the financial statements and of the ratios produced from these figures.

The major findings from the analysis of metadata are as follows. The cost of allowances and composite efficiency ratios are shown for each sample company (see Appendix 10.1). The assumed cost of the allowances for the three years of phase one is then calculated as a proportion of annual turnover, total assets, net pre-tax earnings, and employee numbers. These variables are used by the EU as major criteria for company classification according to size (European Commission 2005b). The ratios produced offer a measure of the company's success in using allowances, acting as a surrogate for environmental degradation, to generate economic activity (sales), economic prosperity (profits) and social benefits (employment). Increases in allowances can be acceptable, even desirable, if they lead to higher increases in sales, earnings, and employment, a situation indicating improving eco-efficiency (Schaltegger et al. 2003). A plethora of empirical studies has attempted the association of company characteristics, including the variables selected here, with managerial choices in the field of environmental accounting, reporting, and financial performance (Klassen and McLaughlin 1996, Cormier and Magnan 1999, King and Lenox 2001, Karim et al. 2006). In Table 10.2, descriptive statistics data drawn from Appendix 10.1 are summarised and presented.

Table 10.2 Descriptive statistical analysis of the sample companies allowance costs discounted by turnover, net earnings, headcount and total assets

	Permits purchase cost expressed as % of turnover			Permits purchase cost expressed as % of net pretax earnings			Permits purchase cost per employee			Permits purchase cost expressed as % of total assets		
	2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
Minimum	0.740	0.020	0.010	–243.970	-19.320	-77.760	1067.000	876.000	720.000	0.420	0.230	0.230
Maximum	32.390	24.040	18.450	1,158.280	2,178.330	7,144.760	81,102.000	61,118.000	88,694.000	34.600	25.500	23.230
Average	9.527	6.462	5.920	161.954	238.172	503.853	20,512.333	16,673.423	18,310.640	6.617	5.561	4.843
Std. deviation	9.648	7.187	6.012	267.226	484.990	1,459.541	24,697.704	19,680.464	22,743.094	7.998	6.008	5.410
Median	6.190	3.750	4.130	62.830	37.690	50.150	9,448.000	7,321.000	6,323.000	4.840	4.600	2.755
Bottom quartile	1.810	0.980	0.980	11.075	10.405	10.320	3,599.500	3,665.500	2,792.000	1.075	1.050	0.943
Top quartile	17.235	10.183	8.110	229.775	201.670	203.350	23,134.000	21,358.000	24,701.000	9.015	7.470	7.125
Positive skewness	0.970	1.178	1.049	2.144	3.089	4.304	1.550	1.454	1.641	2.159	1.822	1.955
Turnover to earnings correlation				0.337	0.304	0.209						

Source: Data analysis from Appendix 10.1

Table 10.3 Number, cumulative percentage, and verified emissions percentage for Greek installations participating in the first EU-ETS phase, classified by size

Classification by size (kt CO_2/year)	Number of installations	% Cumulative percentage of installations	% Cumulative percentage of verified emissions 2005	% Cumulative percentage of verified emissions 2006	% Cumulative percentage of verified emissions 2007
Greater than 5,000	3	2.22	40.0	37.88	36.74
1,001–5,000	14	12.59	84.32	84.60	84.18
501–1,000	7	17.78	91.83	92.10	92.13
251–500	5	21.48	94.61	94.73	94.82
101–250	11	29.63	96.23	96.36	96.60
51–100	20	44.44	98.23	98.22	98.31
26–50	18	57.78	99.10	99.07	99.06
11–25	32	81.48	99.81	99.79	99.79
6–10	12	90.37	99.93	99.92	99.92
5 and below	13	100.00	100.00	100.00	100.00

Source: Data analysis from Appendix 10.1

3.3 Quantity of Emissions

Finally, in Table 10.3, the cumulative percentage of ETS participatory installations and their respective emissions are displayed for the first period of EU-ETS implementation. Table 10.3 demonstrates that although in a Pareto analysis a limited number of companies seem to be responsible for the vast majority of GHG emissions, all participating entities have to bear the administrative costs of a mostly fixed nature, associated with the monitoring and reporting procedures imposed by ETS.

4 Discussion

During phase one of the EU-ETS implementation, verified emissions by the Greek companies were quite close to the allotted permits. Declining demand and the recently introduced use of natural gas offer a partial explanation of the reduced emissions produced by the steel and glass industry. The cost to Greece for purchasing allowances from year 2013 and on has been estimated at €2bn, the overwhelming amount of which goes to the major emitter, PPC. The company has been considering the transfer of the extra cost to the price, taking advantage of its monopolistic position. The EC claims that it is currently working on measures expected to discourage such corporate practices. Such measures should be urgently developed and implemented for a number of reasons: the minimal elasticity of demand for certain products such as electricity (Morgensten et al. 2002); decreasing demand would lead to job losses; further consolidation of the energy market in the case that it is allowed to forward the costs to consumers; and that expensive energy would result in sharp increases to wholesale and retail prices. Such increases, which can escalate to 30% of the price in the case of Greece, may seriously undermine the prospects of developing countries (Rosenfeld et al. 2009).

Limited divergence between allocated and verified emissions allowed the companies to cover their needs or sell surpluses in the national market by improvising on the accounting treatment of such transactions. Withdrawal of IFRIC 3, lack of a relevant international standard, and the usually small value of the amounts involved, have not advocated the foundation by national authorities of a standardised monitoring, recording, and disclosure system of the intra-company transactions. As discussed in the overview, this omission has led to undisclosed windfall profits for a number of ETS participants and to undetected threats for others (Open Europe 2007). For phase two, Greek emissions of GHGs are projected to be 34.7% above the base year levels in 2010 unless additional measures are taken. Thus, either Greek companies prepare in advance to meet the more austere targets or the number of allowances they will need will be higher than the past average. From Appendix 10.1, it can be noted that the cost of allowance acquisition expressed as a percentage of the annual corporate turnover proves exceptionally high (over 5%) for 14 of the 27 sample companies in year 2005, for 11 companies in 2006 and 11 in 2007, a scenario anticipated to get worse when the EUA value soars in a mature competitive market (PointCarbon 2008).

The impact of the assumed cost becomes impressive when expressed as a percentage of the net pre-tax earnings, an outcome of the high breakeven point and operating leverage that characterises manufacturing companies. A high breakeven point functions as a multiplier of the financial impact of revenue changes on the net income and leads to a declining margin of safety (Garrison and Noreen 2000). Thus, if the purchase scenario were active at the research time, 11 of the sample companies would record a strong reduction to their net income, ten would move from profitability to unprofitability, and five would sharply increase recorded losses (see Appendix 10.1). Computations have taken place without considering monitoring, verification, transaction, and reporting costs which can be particularly burdensome to SMEs (Schleich and Benz 2004). Diminishing this negative impact calls for a serious, timely and well-structured plan of re-engineering the whole layout and manufacturing processes of the companies involved. Significant investments in best available techniques, selection and certification of environmentally friendly suppliers, and employee training are necessary to support this shift. Increasing legal requirements and the need for marketing diversification encourage businesses to innovate in order to improve their environmental performance and reduce emissions (Schaltegger et al. 2003). Yet, the evaluation procedures for such innovative investments are difficult (Epstein and Roy 2000) and their payback periods longer than those of other investments since potential benefits often accrue in the future (Schaltegger and Burritt 2000). State intervention can be critical in funding part of the extra costs, sheltering national competitiveness, penalising free-riders and non-conforming companies, and depriving industries from setting sub-optimal standards, but the role of the State in changing market behaviour should be examined independently.

The re-externalisation and impact on corporate earnings of the EU-ETS costs merits considerable attention on its own. Available empirical evidence comes from the power sector, probably because this is the dominant industry in the allowances market. This observation applies particularly to the Greek market with the PPC. Researchers have found that European utilities will have to replace significant parts of electricity-generating capacity in the coming years and their choices will determine the carbon path of Europe for decades (de Leyva and Lekander 2003). Replacement strategies will be pursued in spite of the uncertainty of the investment decisions and the inability to assess the risk to shareholder value (SAM Group 2006). In a hostile environment, with the EU having already slashed 7% of the granted allowances and a EUA price expected to rise above €30/ton, companies will urgently seek ways to externalise the allowances costs when incurred. Yet, in a competitive environment of soaring prices, this may lead to reduced electricity demand. Price responsiveness is low for households and small-scale consumers, but major end-users, such as the power-intensive industries may proceed to self-generation of electricity (Sijm et al. 2006). So, theoretically, while power producers may pass all the opportunity cost of freely allocated allowances to the price, as well as the total cost related to the purchase of these allowances, when the time comes they will do so at a differing pass-through rate, enjoying windfall profits in the first case and decreased profitability in the second.

The annual allowance cost per employee shows a great variation ranging from less than €1,000 to over €80,000 and with an average value of €18,500 per year. In most of the sample cases it exceeds the average annual wages of the company employees. Unexpectedly, larger companies (over 250 employees) report a significantly higher cost per employee. Probable explanations entail either excessive emissions because of their size and structure (PPC is included in that group) or high automation which results in limited staff and, thus, in a small denominator of the fraction. Hypothetically, improvement of the ratio can be achieved by implementing energy efficiency measures expected to reduce the energy used. But if the economic environment is prohibitive, characterised by shortage of government subsidies, tax incentives, or access to loans, a company may simply increase its product prices or relocate. Both these options are open to the sample companies: the former because of the monopolistic (in the case of energy) or oligopolistic (in the case of refineries, cement, and steel industry) environment in which they operate; the latter because companies can move operations to neighbouring countries that do not participate in the EU-ETS. Yet, relocation is not really an option for Greece, since apart from carbon leakages it leads to job, knowledge and wealth leakages.

The allowance cost expressed as a percentage of the assets is difficult to explain without further information since, in its denominator, the ratio comprises three individual variables: size of the company, obsolescence (accumulated depreciation) of its assets, and environmental infrastructure of each company. Obviously, any environmental investment would improve this ratio by reducing its numerator and increasing its denominator. On average, 10 of the 27 sample companies would pay annually for the permits an amount that exceeds 10% of their total assets. This could be an indication of the low efficiency of the company infrastructure, either in terms of fixed assets (obsolescence, poor maintenance) or in terms of current assets (poor quality of raw materials used, highly polluting energy) or both. In either case, the sample companies will have to replace their manufacturing infrastructure before the imminent sale of allowances starts, or pay a substantial percentage of their asset base annually without benefiting the environment.

Standardisation of the accounting entries related to emission trading is a prerequisite for pursuing measurement uniformity and comparability of corporate performance. Companies slow to collect or reluctant to share data should, in our opinion, be mandated to do so by the State. International and industry benchmarking can be used to set the initial expected performance and the best available techniques to achieve this performance. This is a very difficult suggestion in itself, considering the input and output heterogeneity even among installations of the same company or within the same sector. We suggest that the threshold for participation to the ETS scheme urgently increase to involve only those few companies that justify the transaction costs involved in monitoring and reporting requirements. For Greece, it is suggested (Table 10.3) that this threshold be 100 kilotons CO_2 per year, since over 96% of the total emissions result from the operations of the top 40 installations, while the remaining 85 installations produce less than 4% of the annual emissions. Special care is needed to ensure that the change does not result in unfair competition between small companies and their bigger counterparts and that a small size threshold does not provide a perverse incentive for marginal companies to downsize their facilities in order to avoid regulation (Ellerman et al. 2007). The tax system should be reviewed and codified as to whether the freely allocated permits are taxable to recipients and emission fees and other offset activities are tax deductible. Changes should take place in a way which allows the tax system to drive further positive behavioural change without resulting in tax leakages. Border tax adjustments in particular can be used to alleviate adverse competitiveness impacts (Hepburn et al. 2006). Emissions tax reform must be scheduled with particular caution since it can cause ramifications beyond the allowances market (Eichner and Pethig 2009), is strongly context-dependent and may lead to tax interactions with the existing framework diminishing any expected environmental and efficiency gains (Hepburn et al. 2006). Government has both the responsibility and the authority to balance the environment with pending economic concerns. If the suggested transformations do not take place in a timely and effective way, the imminent third phase of the EU-ETS might lead to the detriment of the financial performance of those companies which failed to anticipate the approaching change and prepare themselves accordingly.

5 Summary and Conclusions

The purpose of this study was twofold: to investigate the way in which Greek companies record and treat allowances transactions from an accounting perspective and to predict the impact of future allowance purchases on corporate financial performance and economic prospects.

A major finding of the research is that Greek participants to the EU-ETS, just like their EU counterparts, treat the allowances related accounting entries in an arbitrary way. They ignore the withdrawn IFRIC3 accounting standard as well as relevant academic recommendations. With the exception of few major companies which may have an understanding of the impact of the selected accounting practice on the recorded performance of the company, the rest of the entities seem to overlook this implication and make their choices in a haphazard way. As an outcome, no serious conclusions can be drawn on the intra-temporal and intra-sectoral sustainable performance of the firms or on a comparative analysis of the benefits and drawbacks of the available permit allocation methods such as "grandfathering" and output-based allocation. Companies currently attempt to exploit the scheme rather as a means for gaining windfall profits than as a transient tool to prepare themselves for the auctioning phase expected to follow and contemplate on how to pass future expenses to consumers making use of their oligopolistic situation. Thus, neither the environment nor the businesses gain as designed in the initial aspirations.

A second finding of the study is that unless Greek companies that participate in the EU-ETS proceed to an immediate and intense strategic shift to a more sustainable operation, the introduction of the auctioning phase will be detrimental to their viability, profitability and competitiveness. The allowances acquisition cost, measured with a modest price, is expected to amount to a large proportion of the assets of each company, consume a major part of sales and a huge part of net earnings, and add a serious expense to the cost structure which, in many cases, exceeds total labour costs. The changes necessary to estimate these costs, consider alternative strategies, and select and introduce the best available one, are long-term, demanding and attainable only through a massive concerted stakeholder effort.

Minor findings of the research involve the dissatisfaction of participating companies with the observation that the number of allocated allowances should be based on the maximum rather than average installation operating capacity, as well as the inability and reluctance of the corporate authorities to provide objective and accurate data on the physical and economic allowance-related performance of their installations and the accounting practices followed. The executives contacted seemed to either ignore or underestimate the financial impact of the allowances purchased on their bottom-line, or believe that the ETS is a transient circumstance which will soon expire and thus no standardised procedures should be developed for its management. Another finding, which can partially explain this attitude, is that the use of fines as a penalty for the violators has been a totally ineffective mechanism, since no Greek company has paid a fine, making use of the alternative and much cheaper purchasing or swapping options offered.

It is suggested that future empirical research is warranted to elaborate on the introductory findings of this study and examine the EU-ETS financial impact on an industry basis, in the light of the recent Copenhagen EU commitments, and after standardised accounting procedures have been established by international organisations.

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Appendix 10.1 Cost of allowances and composite efficiency ratios for the years 2005–2007

2005 Installation name	Personnel headcount	Total assets	Annual turnover	Cost of goods sold	Gross operating income	Net pretax earnings	Emissions (in metric tons)	Permits purchase cost (calc at 19.93€ / permit)	Permits purchase cost expressed as % of turnover	Permits purchase cost expressed as % of net pretax earnings	Permits purchase cost per employee	Permits purchase cost expressed as % of total assets
PPC (Public Power Corp SA.)	27,278	12,715,181,000	4,290,860,000	3,413,953,000	876,907,000	201,564,000	52,587,962	1,048,078,083	24.43	519.97	38,422	8.24
Heron ASSAK	20	71,030,000	31,398,000	14,138,000	17,260,000	9,361,000	38,245	762,223	2.43	8.14	38,111	1.07
Aluminum of Greece SA.	1,083	580,618,455	382,139,177	320,884,788	61,254,389	74,039,908	513,388	10,231,823	2.68	13.82	9,448	1.76
Anezoulaki Bros – Fieratex SA.	277	51,220,137	29,610,465	26,885,312	2,725,153	1,220,969	17,494	348,655	1.18	28.56	1,259	0.68
EBZ SA.	960	336,372,394	304,661,404	283,406,772	21,254,632	-13,658,734	273,511	5,451,074	1.79	-39.91	5,678	1.62
KABAΛΑ oil SA.	262	19,638,661	29,440,259	32,455,354	-3,015,095	-31,531,866	91,456	1,822,718	6.19	-5.78	6,957	9.28
EL.PE. (Greek Petroleum) SA.	2,626	3,270,486,000	6,293,075,000	5,662,711,000	630,364,000	454,960,000	2,326,241	46,361,983	0.74	10.19	17,655	1.42
Motor oil of Greece SA	1,377	1,303,161,000	2,923,769,000	2,682,623,000	241,146,000	188,530,000	1,130,994	22,540,710	0.77	11.96	16,369	1.73
Larko-General Minerals and Mining Industry	838	190,319,206	243,949,794	202,420,271	41,529,523	21,322,562	868,478	17,308,767	7.10	81.18	20,655	9.09
Sidenor SA.	354	572,764,186	317,850,742	279,587,378	38,263,364	15,956,162	79,688	4,009,916	1.26	25.13	11,327	0.70
Titan Cement SA.	1,127	970,724,000	439,713,000	265,067,000	174,646,000	145,017,000	4,356,134	86,817,751	19.74	59.87	77,034	8.94
Steel (CHALIPS) SA	170	123,842,638	73,102,479	42,948,425	30,154,054	17,263,305	544,211	10,846,125	14.84	62.83	63,801	8.76
KYKNOS SA.	35	2,591,298	4,022,457	2,807,652	1,214,805	211,436	44,981	896,471	22.29	423.99	25,613	34.60
CaO Hellas – Thessaly company	18	5,887,438	5,244,397	4,399,958	844,438	589,925	73,248	1,459,832	27.84	247.46	81,102	24.80

2005 Installation name	Personnel headcount	Total assets	Annual turnover	Cost of goods sold	Gross operating income	Net pretax earnings	Emissions (in metric tons)	Permits purchase cost (calc at 19.93€ / permit)	Permits purchase cost expressed as % of turnover	Permits purchase cost expressed as % of net pretax earnings	Permits purchase cost per employee	Permits purchase cost expressed as % of total assets
CaO Hellas – Macedonian Company	15	6,890,516	3,302,103	2,933,991	368,111	504,258	53,663	1,069,503	32.39	212.09	71,300	15.52
HEMOS ABE Liquid Asbestos	18	1,245,943	314,118	357,708	-43,590	-147,290	3,094	61,663	19.63	-41.87	3,426	4.95
Gioula SA AE – Cronus	360	210,854,000	66,468,000	47,479,000	18,989,000	1,744,000	67,883	1,352,908	2.04	77.58	3,758	0.64
Vavouliotis-Gounaris-Mitakis SA	200	37,540,992	19,567,385	14,696,721	4,870,664	924,571	91,146	1,816,540	9.28	196.47	9,083	4.84
Vitrouvit SA.	121	25,078,080	8,282,816	8,953,388	-670,572	-3,457,427	10,222	203,724	2.46	-5.89	1,684	0.81
Maliouris Ceramic Industry SA	42	4,749,707	5,121,051	4,391,599	729,452	47,299	27,489	547,856	10.70	1158.28	13,044	11.53
Alpha Ceramica AE	135	14,875,893	10,269,162	7,391,771	2,877,391	499,685	45,446	905,739	8.82	181.26	6,709	6.09
Technoceramica SA	25	2,425,921	2,120,561	1,844,383	276,178	-80,073	9,802	195,354	9.21	-243.97	7,814	8.05
Filkeram Johnson AE	380	54,200,458	32,158,442	24,956,044	7,202,398	300,380	29,474	587,417	1.83	195.56	1,546	1.08
Christodoulidis Ceramic Industry SA	56	14,728,744	4,098,530	2,899,247	1,199,283	48,083	9,670	192,723	4.70	400.81	3,441	1.31
Terra SA	120	19,384,240	9,105,606	6,732,455	2,373,151	399,449	96,725	1,927,729	21.17	482.60	16,064	9.94
Athens Papermill SA	225	78,406,290	43,716,574	36,397,551	7,319,023	965,151	16,548	329,802	0.75	34.17	1,466	0.42
Thrace Papermill SA	420	56,369,057	46,406,783	35,653,394	10,753,389	161,001	22,478	447,987	0.97	278.25	1,067	0.79

(continued)

Appendix 10.1 (continued)

2006 Installation name	Personnel headcount	Total assets	Annual turnover	Cost of goods sold	Gross operating income	Net pretax earnings	Emissions (in metric tons)	Permits purchase cost (calc at 17.83€ / permit)	Permits purchase cost expressed as % of turnover	Permits purchase cost expressed as % of net pretax earnings	Permits purchase cost per employee	Permits purchase cost expressed as % of total assets
PPC (Public Power Corp SA.)	26,208	13,024,893,000	4,787,403,000	4,001,889,000	785,514,000	75,979,000	50,453,003	899,577,043	18.79	1183.98	34,325	6.91
Heron ASSAK	21	72,382,000	33,688,000	22,371,000	11,317,000	9,388,000	10,541	187,946	0.56	2.00	8,950	0.26
Aluminum of Greece SA.	1,150	630,581,414	470,910,849	369,730,028	101,180,821	102,464,427	517,434	9,225,848	1.96	9.00	8,022	1.46
Anezoulaki Bros – Fieratex SA.	275	51,901,171	32,533,461	29,424,974	3,108,487	1,894,334	17,913	319,388	0.98	16.86	1,161	0.62
EBZ SA.	580	333,332,760	165,331,320	142,381,040	22,950,280	3,444,698	183,724	3,275,798	0.02	0.95	5,648	
ΚΑΒΑΛΑ Oil SA.	265	17,188,935	36,211,368	33,935,471	2,275,897	79,271,230	98,397	1,754,418	4.84	2.21	6,620	10.21
EL.PE. (Greek Petroleum) SA.	2,720	3,337,782,000	7,549,893,000	7,113,463,000	436,430,000	281,532,000	2,308,668	41,163,550	0.55	14.62	15,134	1.23
Motor oil of Greece SA	1,430	1,174,157,000	3,629,694,000	3,427,013,000	202,681,000	189,599,000	1,994,441	35,560,883	0.98	18.76	24,868	3.03
Larko – General Minerals and Mining Industry	880	250,046,417	342,987,638	289,761,739	53,225,898	30,136,610	827,442	14,753,290	4.30	48.95	16,765	5.90
Sidenor SA.	347	640,254,809	319,868,734	243,866,974	76,001,760	44,654,734	81,753	1,457,655	0.46	3.26	4,201	0.23
Titan cement SA.	1,380	980,068,000	519,847,000	300,484,000	219,383,000	167,313,000	4,364,690	77,822,422	14.97	46.51	56,393	7.94
Steel (CHALIPS) SA	173	129,855,262	87,978,915	50,039,097	37,939,818	27,162,244	544,147	9,702,141	11.03	35.72	56,082	7.47
KYKNOS SA.	33	2,962,627	4,656,928	3,203,543	1,453,385	233,513	42,364	755,350	16.22	323.47	22,889	25.50
CaO Hellas – Thessaly Company	18	6,388,413	5,104,129	4,573,582	530,547	293,840	58,520	1,043,411	20.44	355.09	57,967	16.33

2006 Installation name	Personnel headcount	Total assets	Annual turnover	Cost of goods sold	Gross operating income	Net pretax earnings	Emissions (in metric tons)	Permits purchase cost (calc at 17.83€ / permit)	Permits purchase cost expressed as % of turnover	Permits purchase cost expressed as % of net pretax earnings	Permits purchase cost per employee	Permits purchase cost expressed as % of total assets
CaO Hellas – Macedonian Company	15	6,639,605	3,812,891	3,253,222	559,669	121,973	51,417	916,765	24.04	751.61	61,118	13.81
HEMOS ABE Liquid Asbestos	19	1,364,254	349,110	150,119	198,990	108,899	**Temporarily ceased manufacturing operations**					
Gioula SA AE – Cronus	362	285,601,000	70,061,000	53,289,000	16,772,000	-4,393,000	47,605	848,797	1.21	-19.32	2,345	0.30
Vavouliotis-Gounaris-Mitakis SA	205	42,911,069	25,110,641	15,530,559	9,580,081	4,003,145	71,200	1,269,496	5.06	31.71	6,193	2.96
Vitrouvit SA.	115	19,222,260	8,224,340	9,184,290	-959,950	-2,450,680	9,812	174,947	2.13	-7.14	1,521	0.91
Maliouris Ceramic Industry SA	39	6,269,799	6,668,118	5,454,710	1,213,407	401,716	28,557	509,171	7.64	126.75	13,056	8.12
Alpha Ceramica AE	136	18,066,090	13,939,334	8,799,623	5,139,711	2,198,015	46,568	830,307	5.96	37.78	6,105	4.60
Technoceramica SA	27	3,088,415	3,371,303	2,349,785	1,021,518	461,294	9,728	173,450	5.14	37.60	6,424	5.62
Filkeram Johnson AE	382	53,754,587	35,140,833	27,865,199	7,275,633	280,575	31,769	566,441	1.61	201.89	1,483	1.05
Christodoulidis Ceramic Industry SA	58	14,130,896	6,330,381	4,968,385	1,361,995	100,621	11,344	202,263	3.20	201.01	3,487	1.43
Terra SA	118	20,732,928	8,563,133	6,018,860	2,544,273	222,685	68,719	1,225,259	14.31	550.22	10,384	5.91
Athens Papermill SA	226	80,264,620	47,924,455	39,229,913	8,694,542	829,601	18,914	337,236	0.70	40.65	1,492	0.42
Thrace Papermill SA	412	5,297,802	39,934,519	32,623,397	7,311,122	16,570	20,244	360,950	0.90	2178.33	876	6.81

(continued)

Appendix 10.1 (continued)

2007 Installation name	Personnel headcount	Total assets	Annual turnover	Cost of goods sold	Gross operating income	Net pretax earnings	Emissions (in metric tons)	Permits purchase cost (calc at 17.50€ / permit)	Permits purchase cost expressed as % of turnover	Permits purchase cost expressed as % of net pretax earnings	Permits purchase cost per employee	Permits purchase cost expressed as % of total assets
PPC (Public power Corp SA.)	24,602	13,368,290,000	5,142,302,000	4,335,212,000	807,090,000	96,910,000	53,073,634	928,788,595	18.06	958.40	37,753	6.95
Heron ASSAK	22	86,096,000	35,148,000	27,591,000	7,557,000	4,308,000	111,501	1,951,268	5.55	45.29	88,694	2.27
Aluminum of Greece SA.	**Data unavailable because of acquisition by agricultural bank of Greece**						514,995	9,012,413				
Anezoulaki Bros – Fieratex SA.	275	50,442,912	34,386,402	32,350,725	2,035,677	79,017	14,405	252,088	0.73	319.03	917	0.50
EBZ SA.	498	351,070,370	98,733,790	82,247,970	16,485,820	-3,967,891	79,460	1,390,550	0.01	-0.35	2,792	
ΚΑΒΑΛΑ OIL SA.	261	20,856,418	30,501,185	27,776,436	2,724,749	23,296	95,111	1,664,443	5.46	7144.76	6,377	7.98
EL.PE. (Greek Petroleum) SA.	2,629	3,851,615,000	7,899,981,000	7,303,211,000	596,770,000	388,730,000	2,293,397	40,134,448	0.51	10.32	15,266	1.04
Motor oil of Greece SA	1,470	1,396,542,000	3,719,133,000	3,494,213,000	224,920,000	208,412,000	2,074,871	36,310,243	0.98	17.42	24,701	2.60
Larko – General Minerals and Mining Industry	850	277,232,074	549,352,142	493,232,508	56,119,634	23,087,633	892,482	15,618,435	2.84	67.65	18,375	5.63
Sidenor SA.	366	660,168,940	394,692,772	326,344,375	68,348,397	37,044,797	86,937	1,521,398	0.39	4.11	4,157	0.23
Titan Cement SA.	1,777	1,004,032,000	535,859,000	322,779,000	213,080,000	159,788,000	4,389,100	76,809,250	14.33	48.07	43,224	7.65
Steel (CHALIPS) SA	173	136,093,486	83,877,656	50,663,835	33,213,820	29,402,167	539,236	9,436,630	11.25	32.10	54,547	6.93
Kyknos SA.	37	3,092,804	4,306,404	2,834,738	1,471,666	102,407	41,052	718,410	16.68	701.52	19,416	23.23
CaO Hellas – Thessaly Company	18	6,158,577	5,812,326	5,088,601	723,724	205,279	48,009	840,158	14.45	409.28	46,675	13.64

2007 Installation name	Personnel headcount	Total assets	Annual turnover	Cost of goods sold	Gross operating income	Net pretax earnings	Emissions (in metric tons)	Permits purchase cost (calc at 17.50€ / permit)	Permits purchase cost expressed as % of turnover	Permits purchase cost expressed as % of net pretax earnings	Permits purchase cost per employee	Permits purchase cost expressed as % of total assets
CaO Hellas – Macedonian Company	16	7,313,796	4,400,300	3,818,693	581,606	37,868	46,384	811,720	18.45	2143.55	50,733	11.10
HEMOS ABE Liquid Asbestos	16	1,191,402	206,365	174,705	31,660	-51,950	**Temporarily ceased manufacturing operations**					
Gioula SA AE – Cronus	362	305,745,000	77,612,000	58,901,000	18,711,000	-2,215,000	50,795	888,913	1.15	-40.13	2,456	0.29
Vavouliotis-Gounaris-Mitakis SA	214	46,569,559	26,842,747	16,543,393	10,299,353	5,379,818	77,325	1,353,188	5.04	25.15	6,323	2.91
Vitrouvit SA.	114	20,481,720	5,416,540	5,532,840	-116,300	-1,919,800	10,416	182,280	3.37	-9.49	1,599	0.89
Maliouris Ceramic Industry SA	43	6,338,155	6,290,993	5,124,905	1,166,088	655,124	29,158	510,265	8.11	77.89	11,867	8.05
Alpha Ceramica AE	139	18,464,264	15,372,837	8,550,034	6,822,802	1,613,503	46,239	809,183	5.26	50.15	5,821	4.38
Technoceramica SA	28	3,159,788	3,408,067	2,622,844	785,223	76,144	8,848	154,840	4.54	203.35	5,530	4.90
Filkeram Johnson AE	382	52,993,898	34,360,196	26,593,294	7,766,902	-653,921	29,058	508,515	1.48	-77.76	1,331	0.96
Christodoulidis Ceramic Industry SA	58	14,873,745	6,036,213	4,212,385	1,823,827	130,499	13,566	237,405	3.93	181.92	4,093	1.60
TERRA SA	119	22,529,255	8,348,580	6,267,025	2,081,555	175,047	19,712	344,960	4.13	197.07	2,899	1.53
Athens Papermill SA	228	75,704,026	53,295,604	44,541,474	8,754,129	345,102	19,541	341,968	0.64	99.09	1,500	0.45
Thrace Papermill SA	415	56,952,951	44,363,462	37,749,354	6,614,108	-2,475,902	17,075	298,813	0.67	-12.07	720	0.52

References

CITL (Community Independent Transaction Log) (2008) [online] [cited 19 January 2009] Available from Internet URL <http://ec.europa.eu/environment/ets>

Cormier D and Magnan M (1999) Corporate environmental disclosure strategies: determinants, costs and benefits *Journal of Accounting, Auditing & Finance* 14.4 429–451

Daskalakis G, Psychogios D and Markellos RN (2009) Modelling CO_2 emission allowance price and derivatives: evidence from the European trading scheme *Journal of Banking and Finance* 33.7 1230–1241

(de) Leyva E and Lekander PA (2003) Climate change for Europe's utilities *The McKinsey Quarterly* 1 121–131

Deloitte Center for Energy Solutions (2009) *Carbon Accounting Challenges; Are You Ready?* [online] [cited 22 October 2009] Available from Internet URL <www.deloitte.com/us/carbonaccounting>

Eichner T and Pethig R (2009) *EU-Type Carbon Emissions Trade and the Distributional Impact of Overlapping Emissions Taxes* CESifo Working Paper Series No. 2579 [online] [cited 22 August 2009] Available from Internet URL <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1360635>

Ellerman D, Buchner B and Carraro C (Eds) (2007) *Allocation in the European Emissions Trading Scheme: Right, Rents and Fairnes*s UK, Cambridge University Press

Epstein MJ and Roy MJ (2000) Strategic evaluation of environmental projects in SMEs *Environmental Quality Management* 9.3 37–47

European Commission Directorate General for Environment (2005) *Review of EU Emissions Trading Scheme: Survey Highlights* Brussels, European Commission

European Commission (2005b) *The New SME Definition: User Guide and Model Declaration* Brussels, EC Enterprise and Industry publications

European Commission Directorate General for Environment, and Ecofys (2007) *Small Installations within the EU Emissions Trading Scheme* Report under the project "Review of EU-ETS", ECS04079 Brussels, European Commission

European Commission (2008) *Proposal for a Directive of the European Parliament and of the Council Amending Directive 2003/87/EC so as to Improve and Extend the Greenhouse Gas Emission Allowance Trading System of the Community* Brussels, European Commission

FEE (Fédération des Experts Comptables Européens) (2005) *FEE Alert Emissions Trading* [online] [cited 23 March 2008] Available from Internet URL <http://www.euractiv.com/29/images/FEE%20Alert%20Emissions%20Trading%200501_tcm29-134783.pdf>

Garrison RH and Noreen EW (2000) *Managerial Accounting* (9th edition) New York McGraw-Hill

Hepburn C, Grubb M, Neuhoff K, Matthes F and Tse M (2006) Auctioning of EU ETS phase II allowances: how and why? *Climate Policy* 6 137–160

IFRIC (International Financial Reporting Interpretations Committee) 2004 *IFRIC 3 Emission Rights* [online] [cited 31 May 2008] Available from Internet URL <http://www.iasplus.com/interps/ifric003.htm>

KAPE CRES (2005) *Directions on the Implementation of an Emissions Trading Scheme in Greece* (KAPE edition) Athens, Centre for Renewable Energy Sources (available only in Greek)

Karim KE, Lacina MJ and Rutledge RW (2006) The association between firm characteristics and the level of environmental disclosure in financial statement footnotes *in* Freedman M and Jaggi B *Environmental Accounting: Commitment and Propaganda* The Netherlands, Elsevier

King A and Lenox M (2001) Does it really pay to be green? An empirical study of firm environmental and financial performance *The Journal of Industrial Ecology* 5.1 105–116

Klassen RD and McLaughlin CP (1996) The impact of environmental management on firm performance *Management Science* 42.8 1199–1214

Morgenstern RD, Pizer WA and Shih JS (2002) Jobs versus the environment: an industry-level perspective *Journal of Environmental Economics and Management* 43.3 412–436

Open Europe (2007) *The high price of hot air: Why the EU Emissions Trading Scheme is an environmental and economic failure* [online] [cited 12 September 2007] Available from Internet URL <www.openeurope.org.uk>

Parker L (2008) *CRS Report for Congress. Climate Change and the EU Emissions Trading Scheme (ETS): Kyoto and Beyond* Washington DC

PointCarbon (2007) *Carbon 2007 – A new climate for carbon trading* [online] [cited 29 September 2007] Available from Internet URL <http://www.pointcarbon.com/getfile.php/fileelement_105366/Carbon_2007_final.pdf >

PointCarbon (2008) *Carbon 2008 – Post 2012 is now* [online] [cited 7 May 2008] Available from Internet URL <http://www.pointcarbon.com>

PwC and IETA (PricewaterhouseCoopers and International Emissions Trading Association) (2007) *Trouble-entry accounting: Uncertainty in accounting for the EU Emissions Trading Scheme and Certified Emission Reduction Industries* [online] [cited 19 December 2009] Available from Internet URL <www.pwc.com/nl_NL/climate-change/assets/documents/trouble-entry-may07.pdf>

Rosenfeld J, Remes J, Mendonca L, Hu W, Palani S and Sethi U (2009) *Averting the Next Energy Crisis: The Demand Challenge* USA, McKinsey Global Institute

SAM (Sustainable Asset Management) Group (2006) *Carbonizing Valuation: Assessing Corporate Value at Risk from Carbon* [online] [cited 24 December 2009] Available from Internet URL <www.sam-group.com/downloads/studies/ sam_carbonizing_short_e.pdf>

Schaltegger S and Burritt R (2000) *Contemporary Environmental Accounting: Issues, Concepts and Practice* Sheffield, Greenleaf Publishing

Schaltegger S, Burritt R and Petersen H (2003) *An Introduction to Corporate Environmental Management: Striving for sustainability* Sheffield, Greenleaf Publishing

Schleich J and Benz R (2004) Transaction costs for small and medium sized companies *Intereconomics* 39.3 121–123

Schreuder Y (2009) *The Corporate Greenhouse: Climate Change Policy in a Globalizing World* London, Zed Books Ltd

Sijm J, Neuhoff K and Chen Y (2006) CO_2 cost pass-through and windfall profits in the power sector *Climate Policy* 6 49–72

Chapter 11
Environmental Management Accounting: Comparing and Linking Requirements at Micro and Macro Levels – A Practitioner's View

Christine Jasch

Abstract The paper compares corporate disclosure reqirements to statistical agencies about material and energy consumption, environmental investments and expenditures, as specified by the Integrated System of Environmental-Economic Accounting (SEEA) for the macro level, with the guidance document on environmental management accounting, published by the International Federation of Accountants for the micro level. The paper discusses the definitions of materials and products, environmental costs and investments contained in both documents and highlights differences in the approaches taken towards environmental protection and integrated pollution prevention. The resulting recommendations for harmonisation have also been introduced into the curent SEEA revision process.

Keywords Environmental management accounting • Material flow accounting • Supply chain • Environmental expenditure • Environmental investments

1 Introduction

Environmental accounting has a micro as well as a macro level of development. At the micro level, companies are assembling and aggregating data for their internal use as well as for disclosure to external stakeholders. At the macro level, statistical and environmental protection agencies are collecting information, aggregating it and providing information for decisions in science and environmental politics.

The core part of this paper is a comparison of definitions and disclosure requirements for environmental accounting at national and corporate levels. It results in recommendations to statistical agencies which are collecting this type of data worldwide, based on the *Integrated System of Environmental-Economic Accounting* (SEEA) handbook (UN SEEA 2003). Through participation of the author in the

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revision process of the London Group on Environmental Accounting which has accepted the request by the United Nations (UN) Committee of Experts on Environmental-Economic Accounting to take a leading role in the revision of the SEEA-2003, the worldwide handbook of national environmental-economic accounting (UN SEEA 2003), these recommendations have been introduced into the revision process.

Environmental-economic accounting brings together economic and environmental information in a common framework to measure the contribution of the environment to the economy and the impact of the economy on the environment. SEEA is a satellite of the 1993 System of National Accounts (SNA) (UN SNA 1993). The SEEA 2003 handbook provides a common framework for economic and environmental information, permitting a consistent analysis of the contribution of the environment to the economy and the impact of the economy on the environment. It is intended to meet the needs of policy-makers by providing indicators and descriptive statistics to monitor the interaction between the economy and environment. It is also intended to serve as a tool for strategic planning and policy analysis to identify more sustainable development paths (UN SEEA 2003).

Four categories of accounts run through the SEEA handbook. These are:

1. Physical and hybrid flow accounts of material and energy, related to material flow accounting at the corporate level, and hybrid accounts link the physical accounts with economic (monetary) flows called the National Accounting Matrix with Environmental Accounts (NAMEA).
2. Accounts that portray environmental transactions in the existing SNA in more detail, e.g. expenditures made by businesses, governments and households to protect the environment.
3. Environmental asset accounts in physical and monetary terms with three categories of natural capital: natural resource stocks, land and ecosystems.
4. Accounts that show how existing SNA aggregates can be modified to account for depletion and degradation of the environment and for environmental defensive expenditure.

In 2005, a guidance document on corporate environmental management accounting (EMA) was developed for the International Federation of Accountants (IFAC) (Savage and Jasch 2005). It is based on a publication about principles and procedures for EMA written for the UN's Division for Sustainable Development (UNDSD) (Jasch 2001).

According to the UNDSD definition, two types of information are considered under EMA: physical and monetary information. Physical information includes data on the use, flows and final destiny of energy, water, materials and wastes. EMA places a particular emphasis on physical information because: (1) use of energy, water and materials, as well as the generation of waste and emissions, are directly related to many of the environmental impacts of organisational operations; and (2) materials purchase costs are a major cost driver in many organisations.

In recent years, both documents, the EMA guidance document of IFAC and the principles and procedures for EMA by UNDSD, have been applied in several case studies worldwide, with the focus on developing internal corporate procedures and standards for data collection and disclosure. Experience shows that national disclosure requirements by statistical agencies vary slightly, as definitions are not consistently applied, even though referencing the same SEEA 2003 framework document (e.g. the results of case studies with international companies like Danisco, Verbund and OMV published in Monkoe and Jasch 2008, and Jasch 2009). International corporations installing world-wide information systems to fulfil their disclosure requirements and voluntary sustainability reporting goals can find significant difficulties in aggregating data from different countries, if those definitions differ. Examples exist of different definitions of environmental investments, different approaches regarding depreciation and confusion regarding the collection of costs, expenditure, savings or cash flow related data.

Some companies publish data on their material flows, waste and emissions and related environmental investments and costs in their annual reporting. The Global Reporting Initiative (GRI) published its latest version of global reporting requirements in October 2006 (GRI 2006). They contain a set of sustainability performance indicators and are supplemented by indicator protocols, which specify measurement and disclosure requirements in detail. The GRI definition of environmental expenditure directly references the IFAC EMA guidance document.

The aim of this paper is to provide further consistency of data requirements for statistical purposes with the structure of financial accounting systems and with the definitions in the IFAC and GRI guidance documents. This purpose was funded within a research project under the *Factory of Tomorrow Framework* of the Austrian Ministry of Transport, Innovation and Technology. It contained the participation in the SEEA working group for two years as well as activities with Statistik Austria and Eurostat (the statistical arm of the European Commission). The outcome of the analysis of differences in definitions and interpretations were fed into the SEEA revision process (which was still running when the project was finished) and into the Austrian assessment for corporate environmental costs for 2006 and 2007 by Statistik Austria. The recommendations support the design of harmonised corporate information systems and help provide consistent and comparable data at both micro and macro levels.

Improved and harmonised data quality is essential for corporations as well as for aggregated statistical analysis (e.g. Haberl et al. 2006, Sprenger 2007). Type of EMA data provides the ground for several decisions, ranging from investment choices, benchmarking of production sites to scientific projects and shaping of political instruments such as eco-labelling or emissions trading (Klöpffer and Renner 2008, Wernick and Irwin 2005). In addition, with improved harmonisation, the time needed for data assessments and aggregations can be reduced significantly, for both corporations and statistical agencies.

The paper proceeds as follows: the first section deals with issues relating to material flow accounting (MFA) which can be undertaken for different system boundaries. While the concept of a mass balance, in principle, is the same for the micro and macro levels, in effect, the definitions differ and hamper consistency and the possibility for of data aggregation.

The following sections deal with issues related to the classification of environmental costs. At the micro level, these are clearly distinguished into:

1. Material purchase costs for product and non-product outputs
2. Costs for waste and emission control
3. Costs for pollution prevention and general environmental management

After recording total annual environmental costs by financial accounting categories, costs can be distributed to the environmental domains affected. In contrast, at the macro level, costs for material inputs and pollution prevention are not consistently defined. Cost assessment questionnaires sent out by statistical agencies start with costs classified by environmental domain effected which makes it difficult to relate them to financial accounts and thus secure completeness of the data reported. The approach taken by SEEA to apply the sole environmental purpose criterion and thereby by definition to exclude all activities which make sense to corporations in terms of cost savings, e.g. by reduced energy and material inputs and efficiency gains, is critically discussed and is in complete contrast with the merits of cleaner production and pollution prevention.

The next section addresses issues related to the classification of environmental investments where again the SEEA approach excludes measures to reduce the input of materials, energy and water and increases in resource efficiency, measures which have a positive payback and measures related to reduction of the environmental impact of products, thereby, in effect, excluding all integrated cleaner technologies. Thus, the relevance of the data assessed by the statistical agencies is open to question. Finally, recommendations for the revision of SEEA are summarised in the last section.

2 Issues Relating to Material Flow Accounting

2.1 Material Flow Accounting According to IFAC and UN DSD

Probably the most significant difference between micro and macro definitions of EMA is related to the clarification and consistent application of the definitions for materials and products. The IFAC guidance document for EMA (Savage and Jasch 2005) distinguishes between raw and auxiliary materials, packaging materials and operating materials. Raw and auxiliary materials are inputs to the finished products of a company. For the purposes of EMA, loss percentages have to be calculated or estimated as not all raw material inputs are converted into products. These losses make up a significant share of the costs of waste. Such conversion is a conventional management accounting issue. Packaging materials are purchased for shipping of the products. Packaging materials leave the company with the product but in many cases a certain loss occurs during production which mostly results in solid waste. Operating materials, by definition, are not part of the product. However, they are necessary for production purposes. They may contain highly relevant materials from an environmental point of view: cleaning materials, lubricants, chemicals, and maintenance equipment. As operating materials are not part of the product they become part of waste and emissions. The use of operating materials is often recorded in the different production cost centres using them. This is normally not the case for raw and auxiliary materials. Operating materials are often monitored by production planning systems without accounting by cost centres for losses during the different production steps (Fichter et al. 1997, 1999). Material flow accounting focuses on tracing the flow of raw and auxiliary materials in both physical and monetary terms as well as operating materials via the different production steps and process cost centres (ISO 2009a).

The United Nations Expert Working Group on EMA, which highlights both the physical and monetary sides of EMA, has developed the following definition for EMA. According to the UN Group EMA is broadly defined to be:

> the identification, collection, analysis and use of two types of information for internal decision making: physical information on the use, flows and destinies of energy, water and materials (including wastes) and monetary information on environment-related costs, earnings and savings (Jasch 2001:11)

Under the physical accounting side of EMA, an organisation should try to track all physical inputs and outputs and ensure that no significant amounts of energy, water or other materials are unaccounted for. The accounting for all energy, water, materials and wastes flowing into and out of an organisation is called a materials balance and sometimes also referred to as input–output balance, mass balance or eco-balance (United Nations Environment Program and United Nations Industrial Development Organization 1991, German Environmental Protection Agency/German Environment Ministry 1995, Pojasek 1997, Environmental Protection Agency of Baden-Würthemberg 1999).

Many organisations perform energy balances and water balances separately from other materials balances. As the term *input–output balance* implies, the underlying assumption is that all physical inputs must eventually become outputs – either physical products or waste and emissions – and the inputs and outputs must balance. The level of precision of a materials balance can vary, depending on the specific purposes of the information collection and the availability and quality of data.

Materials inputs are any energy, water or other materials that enter an organisation. Outputs are any products, wastes or other materials that leave an organisation. Any output that is not a product output is, by definition, a non-product output (NPO). In organisations that use energy and materials but do not manufacture physical products, such as transport or other service sector companies, all energy, water and other materials used will eventually leave as non-product output (Savage and Jasch 2005).

The IFAC guidance document on EMA uses the term NPO synonymously with the term *waste and emissions*. The Japanese guide for material flow cost accounting is based on the same concept and distinguishes output into positive and negative products (METI 2007). The physical categories described by IFAC are also in line

Table 11.1 Overview of the input–output material flow balance

Inputs	Outputs
Raw materials	*Product output*
Auxiliary materials	Products and by-products
Packaging	*Non-product output (NPO)*
Operating materials	Solid waste
Energy	Waste water
Water	Emissions to air

Table 11.2 System boundaries for material flow accounting

Inputs	System boundaries	Outputs
	Nations and regions	
Materials ⇒	Industry sectors	⇒ Product output
Energy ⇒	Corporations	⇒ Non-product output
Water ⇒	Production processes	
	Products	

with the general structure of ISO 14031 for environmental performance indicators for operational systems (ISO 2000), which are referenced in ISO 14001, the standard for environmental management systems (ISO 1996). The upcoming ISO standard on material flow cost accounting (ISO 2009a) is based on the same concept. The typical outline for an input–output balance is show in Table 11.1 (Jasch 2009).

2.2 Material Flow Accounting Along Supply Chains

Material flow accounting can be undertaken for several system boundaries within a supply chain and can be aggregated across these system boundaries (see Table 11.2 from Jasch 2009). For external disclosure in sustainability reports, the system boundary preferably relates to the consolidation units. The financial accounting consolidation rules for subsidiaries and joint ventures should also be applied for the environmental and social data (GRI 2006). For internal EMA purposes, breaking down data one step further to cost centres and production processes, different products or even machines, can constitute a helpful tool for process optimisation. It then becomes the task of process technicians rather than the accounting profession to tackle and trace the necessary data. At a macro level, some of the material flows reported by organisations are aggregated by industry sector (NACE) codes, regions and nations and cross-checked with other data sources.

EMA data are increasingly being used e.g. for life cycle assessments (LCA) based on ISO 14040 (2006) (Klöpffer and Renner 2008). LCAs comprise two levels: internal company data and data collected along stages of the life cycle. Internal company data need to be attributed to production processes and production steps (e.g. at the cost centre level) and later to the products produced for companies producing more than one product. On the external side, the system boundary for a LCA follows the product throughout its life cycle by adding upstream and downstream life cycle stages along supply chains. This method, based on material flow thinking, has been incorporated into ISO 14040, the world wide ISO standard for life cycle assessments (ISO 2006).

LCAs therefore require good quality internal data at the cost centre level. In addition, LCAs may require data from companies outside the direct sphere of influence of the person attempting to perform the LCA. Furthermore, as most companies produce more than one product and use a number of processes, LCAs require data not available from external environmental or sustainability reports, which are published at the system boundary of the company or corporation and not at the level of the process and product related inputs and outputs; such data from the corporate level cannot be directly used for LCAs in multi-product companies.

An ISO survey published in 2008 shows that to the end of 2007, at least 154,572 certificates of compliance with ISO 14001:2004 had been issued in 148 countries (ISO 2009b). This has had significant impact on supply chains, as companies monitor their suppliers for their environmental performance within ISO 14001. At the same time, comparability of performance indicators and the consistency of financial and technical information systems are still very weak and not enough data is being disclosed, as only the environmental policy has to be made publicly available under ISO 14001.

Because of the lack of other data available along the supply chain, people performing LCAs try to obtain material flow data from national statistics, but encounter several problems related with data availability, timeliness, too high a level of aggregation, and poor data quality. This data is typically only available by industry sectors (NACE Codes).[1] So while LCA in general terms may work at the macro level by linking highly aggregated sector specific information on material flows with environmental impacts and providing very general information on environmental impacts from production sectors, the connection to data collected at the micro level remains weak.

LCAs based on macro data are being used for political decision-making, for example, environmental labelling (e.g. Chiu and Ward 2009, Klöpffer and Renner 2008). However, the data are inadequate as they may point in the wrong direction because of poor quality or do not provide enough information for companies when making decisions about their eco-design or procurement. The sector specific data provided on a NACE code basis is not sufficiently product specific.

Ideally, the mass balance, as shown in Table 11.1 with its sub-categorisation of raw, auxiliary and operating materials, water and energy, would be available for each NACE industry sub-sector. But nowadays the input side of national statistics is incomplete as only raw materials are accounted for, while auxiliary and operating materials which are responsible for much of the environmental impacts are neglected. In order to be able to use the data published by statistical agencies,

[1]NACE Code is a pan-European classification system which groups organisations according to their business activities. It assigns a unique 5 or 6 digit code to each industry sector, for example, DA.15.83 – Manufacture of Sugar. The list of NACE codes is available at http://ec.europa.eu/environment/emas/pdf/general/nacecodes_en.pdf.

e.g. for LCAs, it would be necessary to consistently distinguish the inputs and outputs of a NACE sub-sector in physical and monetary units and to separate the monetary data into products and services.

2.3 Material Flow Accounting at the Macro Level

Material flow accounts (MFA) at the national level comprise:

(a) Compilations of the overall material inputs into national economies;
(b) Changes of material stock within the economic system; and
(c) Material outputs to other economies or to the environment.

The fundamental concept of MFA of the UN SEEA is different from the input–output structure at the micro level. SEEA deals with products, natural resources, ecosystem inputs and residuals. The concept of products is taken from the SNA. The accounting system of the SNA measures the flows of products (economic goods and services) and shows how in a closed economy some flows are used to produce other goods and services in the current period (intermediate consumption) or in future (capital formation). In addition, some economic goods and services are used to satisfy current human wants (final consumption). Transactions with the economies of other countries via imports and exports are also captured.

Four different types of flows are distinguished in the SEEA (UN SEEA 2003:30):

1. *Products* are goods and services produced within the economic sphere and used within it, including flows of goods and services between the national economy and the rest of the world.
2. *Natural resources* cover mineral and energy, water and biological resources.
3. *Ecosystem inputs* cover the water and other natural inputs (e.g., nutrients, carbon dioxide) required by plants and animals for growth, and the oxygen necessary for combustion.
4. *Residuals* are the incidental and undesired outputs from the economy which generally have no economic value and may be recycled, stored within the economy or (more usually at present) discharged into the environment. *Residuals* is the single word used to cover solid, liquid and gaseous wastes.'

Physical flow accounts consist of merging accounts for products, natural resources, ecosystem inputs, and residuals, with each account being expressed in terms of (a) supply to the economy and (b) use by the economy (see Table 11.3).

Table 11.3 Physical flow accounts according to SEEA

Inputs = supply to the economy	Outputs = use by the economy
Products	Products
Natural resources	Residuals
Ecosystem inputs	

SEEA's focus is to look at the flow of entities into the economy from the environment and those that flow from the economy to the environment (Eurostat 2001, Hinterberger et al. 2003). The inputs flowing to the economy from the environment are divided into: (a) natural resources typically mineral and biological resources and (b) ecosystem inputs the water and air necessary for all life forms.

The flows from the economy to the environment consist of gaseous, liquid and solid wastes. The term *residuals* is used to encompass all the outflows from the economy which use environmental media (air, water, ground) as a disposal sink. Residuals can be clearly identified as non-product output (waste and emissions) at the micro level.

Unfortunately, all the material inputs remain vague and inconsistent with accounting terminology and records. SEEA does not make a clear distinction between materials and products (likewise Kleijn 2001). At times, SEEA refers to raw materials only and other times, it uses the terms materials and products as being identical. The terminology is not used consistently and definitions of terms used are missing. In addition, there is no guidance provided on the recording of operating materials. Table 11.3.18 on page 139 of SEEA handbook summarises all input of the production sector as *total material inputs* including intermediate consumption, extraction of natural resources, ecosystem inputs and re-absorption of materials. However in other sections the term *materials* is used interchangeably with the term *products* and sometimes *physical flows* in general.

Products in SEEA can be classified according to different criteria and objectives. The 1993 SNA introduced the Central Product Classification for this purpose (UN SEEA 2003:104). With the Central Product Classification developed primarily for economic analysis, UN SEEA (2003) notes that supplementary classifications may be used for the analysis of physical characteristics. It references the chemical abstract system together with a toxicity database to be used to identify harmful effects of chemicals. But this is of little help as long as the division into raw and auxiliary and operating materials is not established.

3 Issues Relating to the Classification of Environmental Costs

While the previous section dealt with the recording of physical material flows in national statistics and corporate accounts, this section focuses on the related monetary data and the perception of what constitutes environmental costs.

The distinction between end-of-pipe treatment and integrated prevention is a major achievement in cleaner production and highlights the paradigm shift from emission permits and aftercare to the precautionary principle. The shift in total environmental costs from treatment to prevention started with the application of environmental management systems about 15 years ago (European Parliament and Council 1993, ISO 1996), but still is not adequately reflected in environmental statistics (European Commission – Eurostat 2001, European Commission 2001).

3.1 Environmental Costs According to IFAC

During the preparation of the IFAC EMA guidance document (Savage and Jasch 2005), cost definitions from a variety of international sources were reviewed and a set of cost categories was developed that represents not only widely accepted international practice, but also emerging best practice. Table 11.4 defines the set of environment-related EMA cost categories at the micro level, which conform to the IFAC and UNDSD approaches.

Most EMA cost categories have sub-categories relating to traditional financial accounts, for example, equipment depreciation, raw and auxiliary materials, operating materials, and personnel. These sub-categories are discussed in greater detail in the IFAC guidance document.

The IFAC EMA guidance document is not a financial accounting standard (dealing with expenditures and disclosure requirements). It is noted however that most companies, particularly those of small and medium size, do not have an independent management accounting system. For internal decision-making, they use data initially developed for financial accounting and external reporting purposes, sometimes with a few minor adjustments. Instead, the document's focus is on the information needs of internal management, and the terminology used applies to cost accounting. The focus of the IFAC EMA guidance document is on recording actual annual environmental costs or expenditures, not on investment appraisal or calculating savings. The quality of investment appraisal tools and calculations of savings is directly related to the quality of the data provided by the corporate information system.

Table 11.4 Environment related cost categories at the micro level

1. *Materials costs of product outputs*
Includes the share of the *purchase costs* of materials used for production that become product output.
2. *Materials costs of non-product outputs*
Includes the share of *purchase (and sometimes processing) costs* of energy, water and other materials that become non-product output (waste and emissions).
3. *Waste and emission control costs*
Includes the costs for *handling, treatment and disposal* of waste and emissions. These are the typical end-of-pipe approaches, starting with the production output and not the material input and prevention measures.
4. Prevention and other environmental management costs
Includes the costs of *preventive environmental management activities* such as installing environmental management systems and integrated pollution prevention measures.
5. *Research and development costs*
Includes the costs for *research and development* projects related to environmental issues.

Source: Savage and Jasch (2005)

3.2 Classification of Environmental Expenditure by Environmental Domains and Financial Accounts

In accordance with SEEA requirements and the IFAC EMA structure, the assessment template (see Table 11.5) for environmental costs recommended by the Institute for Environmental Management and Economics[2] distributes the costs to the environmental domains affected. They are classified as:

- Air and climate
- Waste water
- Waste

Table 11.5 Distribution of environment related costs by EMA cost categories and accounts

Environment-related cost categories	Total annual costs with subsequent option to be distributed by environmental domains affected
1. *Materials costs of product outputs*	
• Raw and auxiliary materials	
• Packaging materials	
• Water	
2. *Materials costs of non-product outputs*	
• Raw and auxiliary materials	
• Packaging materials	
• Operating materials	
• Water	
• Energy	
• Processing costs	
3. *Waste and emission control costs*	
• Equipment depreciation	
• Operating materials	
• Water and energy	
• Internal personnel	
• External services	
• Fees, taxes and permits	
• Fines	
• Insurance	
• Remediation and compensation	
4. *Preventive and other environmental management costs*	
• Equipment depreciation	
• Operating materials, water, energy	
• Internal personnel	
• External services	
• Other environmental management costs	
5. *Research and development costs*	

[2] http://www.ioew.at/ioew/d-ioew-set.html

- Soil and groundwater
- Noise and vibration
- Biodiversity and landscaping
- Radiation
- General environmental management activities

These are a slightly modified version of the environmental domains that European statistical offices must use in reporting businesses' environmental protection expenditures to Eurostat and SEEA. The classification that SEEA 2003 suggests for organising environmental protection activities, expenditures and products, is the Classification of Environmental Protection Activities (CEPA). Within the CEPA, environmental protection activities are first classified by environmental domain (air, waste, nature protection) and then by type of measure (prevention, treatment) (UN SEEA 2003:201).

For practical reasons, when installing a corporate EMA system or collecting data for external reporting, it is highly recommended to approach this in the reverse order. The environmental costs available from accounting information systems should be first assessed by standard accounting categories as total annual costs and only then be assigned to the environmental domains affected (see Table 11.5 modified from Savage and Jasch 2005 and Jasch 2009). Therefore, it becomes the task of the accountants to set up a consistent and complete data information system with support from environmental managers.

The CEPA approach and the questionnaires sent out by statistical agencies for data collection view this the other way round. They ask for environmental domains and thus the questionnaire is being answered by the environmental manager who often has no direct access to the accounting system, and no overview of the total corporate cost structure. Thus the information reported is often incomplete and inconsistent.

3.3 Environmental Expenditure According to SEEA

The IFAC and UNDSD approach primarily distinguish between material costs for product and non-product output as well as costs for treatment versus prevention. It is emphasised that with more sophisticated environmental protection approaches, corporations are shifting from treatment to prevention thus reducing material inputs and that this shift should also be the focus of environmental management and reporting.

In contrast, the CEPA classification focuses on treatment activities and the impact on environmental media (air, water and ground). The classification by definition excludes all activities which make sense to corporations financially, e.g. by reduced energy and material inputs and efficiency gains. Activities are only to be recorded if: (a) the primary purpose is environmental protection and (b) if the expenses do not have a positive return on investment. By this definition, most activities that companies are taking for integrated pollution prevention are excluded.

In order to understand the SEEA approach to environmental expenditure it is necessary to understand the underlying concept of the environmental domain of interest (UN SEEA 2003:169):

> The two main purposes designated to be of environmental interest are protection of the environment and the management of natural resources and their exploitation. Damage avoidance and treatment may also be included in the field of interest though these activities are more concerned with rectifying damage already done than with preventing it in the first place. Lastly, and perhaps less obviously, minimisation of natural hazards may be included although these are activities to protect the economy from the environment where the others are concerned with protecting the environment from the economy. For simplicity, the expression 'environmental activity' is used as shorthand for all the environmentally related purposes just described.

The accounts for environmental protection and resource management established in SEEA aim to identify and measure society's response to environmental concerns through:

- The supply and demand for environmental goods and services
- The adoption of production and consumption behaviour aimed at preventing environmental degradation
- The management of environmental resources in a sustainable way

The approach taken by SEEA (UN SEEA 2003:170) in identifying environmental activity is to subdivide products and industries into those which are typical, or characteristic, of environmental activity and those which are not. Identification is based on the assumption that environmental protection is a distinctive separate satellite system to normal production. But this neglects the fact that currently, in nearly all sectors, environmental management systems have been installed. Their core part is to take initiatives to reduce the environmental impact of production and products and in addition develop more sustainable products.

SEEA tries to solve the issue by introducing a further classification into the supply and use matrix that identifies the purpose of the expenditure undertaken. The purposes of interest are classified as:

- Protection of the environment
- Management and exploitation of natural resources
- Environmentally beneficial activities
- Minimisation of natural hazards

The CEPA definition (UN SEEA 2003:559) states:

> Protection of ambient air and climate comprises measures and activities aimed at the reduction of emissions into the ambient air or ambient concentrations of air pollutants as well as to measures and activities aimed at the control of emissions of greenhouse gases and gases that adversely affect the stratospheric ozone layer. Excluded are measures undertaken for cost saving reasons. (e.g. energy saving).

CEPA 2000 is designed to classify transactions and activities whose primary purpose is environmental protection. The management of natural resources, for example water supply, and the prevention of natural hazards, such as landslides and floods, are not included in CEPA. But the every-day decisions of organisations, investments and current expenditure items are no longer simply either for environmental protection or production related. Success of integrated technologies and management systems, e.g. integrated quality, environment and health and safety systems, makes environmental protection no longer a satellite system to general management, but an incorporated strategy and procedure. Several companies have realised cost savings from shifts to less hazardous materials and shifts to renewable energy sources and gains in material and energy efficiency. But no such measures would qualify as environmental protection expenditure under SEEA, as the sole purpose of interest would not be protection of the environment as they are most likely have net economic benefits.

The same fundamental conceptual problem arises regarding the definitions of environmental products and environmental goods and service industry. As long as environmental protection is a clearly identifiable additional treatment or clean-up activity, the basic concept of SEEA provides useful results. Since the establishment of integrated pollution prevention into general management systems, the satellite approach to environmental protection no longer adequately reflects reality in production companies. The persistence of national statistics to demand data following an outdated paradigm leads to resistance of companies being requested to produce this information out of accounts and management systems which follow a completely different logic (see Sprenger 2007).

SEEA itself recognizes that ‘one of the most difficult distinctions to make is whether the primary purpose of the spending is environmental protection, or whether environmental protection is simply a result of decisions taken for some other purpose’ (UN SEEA 2003:198). An example is provided of equipment expenditure which may reduce pollutant emissions but which may also be more energy efficient.

However, SEEA does not include the energy efficient equipment – a decision which is not really understandable from an environmental point of view. This decision has resulted in a strong decline in recorded environmental investments since 1990 (Federal Statistical Office 2006), which is not at all related to degradation in the state of environment. At the same time, companies have invested in integrated pollution prevention techniques and management systems and actually improved environmental performance in relation to production but these investments are excluded from reporting to statistical agencies.

SEEA also recognises practical data collection problems such as trying to estimate the cost of the additional clean part of new capital equipment, particularly where the clean element becomes a standard part of the equipment and there is no dirty alternative. This dilemma could be solved by introducing a criterion for actual environmental impact of a measure, a criterion that corporations often apply when defining the environmental share of a measure.

The SEEA approach to environmental expenditure explicitly only ‘concentrates on steps taken to deal with residuals and does not explicitly consider protection of the environment through means of water and energy conservation or the effects of recycling’ (UN SEEA 2003:215). In effect, this means that the SEEA approach only focuses on the output of waste and emissions and neglects all activities that reduce the inputs of materials, water and energy. Therefore, SEEA is in complete contrast to the cleaner production and pollution prevention approach.

Relevant activities and expenditures are identified by the criterion of the primary purpose. To find out if the primary purpose definition applies, SEEA proposes the following criteria:

(A) The pure purpose criterion: activities and expenditure, where the main objective is protecting the environment, are included in full. This criterion works best where the main objective of protecting the environment is unambiguous, for example end-of-pipe capital expenditure.

(B) The extra-cost criterion: is used to identify the portion of the cost of environmentally friendly technologies and changes in processes and products to be attributed to environmental protection. The investment and operating expenditures are compared with those of a 'standard' or less environmentally beneficial alternative, if there is one, or the estimated additional cost of incorporating the environmentally beneficial feature. Only the extra expenditure is included.

(C) The net-cost criterion: only expenditure undertaken for environmental protection purposes which leads to a net increase in cost, that is where spending exceeds any savings or income arising before the net cost was actually incurred, is included. When expenditure is recorded, this criterion only applies to operating expenditure.

(D) The compliance criterion: Expenditure undertaken with the main objective of protecting the environment but specifically in order to comply with environmental protection legislation, conventions and voluntary agreements. This can be further sub-divided to show those activities and transactions undertaken in order to comply with legislation only (UN SEEA 2003:200).

The decision of SEEA to exclude all environmental protection activities which pay off has in addition contributed to the expectation that environmental protection is costly. But, as environmental prevention projects in the last 20 years have shown very successfully, it is the neglect of environmental protection and resource management that is costly.

The most convincing argument about integrated measures is that they pay off for the organisation: to exclude integrated measures from environmental statistics really only captures a very tiny and unimportant picture of pollution prevention. However, companies need to record the costs for resource flows in order to be able to measure the financial benefits of pollution prevention. IFAC therefore explicitly introduced the costs for non-product output and ISO developed a worldwide standard for material flow cost accounting. Unfortunately, costs related with resource management are excluded from the environmental expenditure definition of SEEA.

4 Issues Related to the Classification of Environmental Investments

4.1 Environmental Investments According to IFAC

The IFAC EMA guidance document clearly separates equipment used for control and treatment and equipment used for integrated pollution prevention. The IFAC category *equipment depreciation costs* represents the investment costs recorded on an annual basis over the expected lifetime of the equipment. In accordance with financial accounting rules, an investment is recorded at the point of time when it is implemented and not during the project planning and construction phase where there are already cash outflows for the company, e.g. for consultant engineering services. As the focus is on annual costs, annual depreciation is collected for total annual costs. However, in the assessment template which was developed for data assessment (based on Table 11.5), the annual investment volume is also collected, as requested by some national statistical institutes.

Examples of waste and emission control equipment include:

- Waste handling equipment such as solid waste dumpsters, waste transportation equipment
- Waste and emissions treatment equipment such as wastewater treatment systems, air scrubbers
- Waste disposal equipment such as earth moving equipment for an on-site landfill

Most equipment used for prevention and other environmental management may be closely integrated into production equipment, for example, a solvent distillation and re-use system that is an integral and automated part of a chemical manufacturing process. In other cases, equipment such as a high efficiency paint spray gun, may simply contribute to preventive environmental management because it inherently uses energy or raw materials more efficiently and produces less waste than alternative equipment. In such cases, an organisation may wish to estimate what percentage, if any, of the annual depreciation costs for the equipment should be designated as environment-related. The primary reason(s) for purchasing the particular piece of equipment may be used as the basis for the estimation.

The IFAC document allows the company to estimate the environmental share of integrated technologies based on environmental impact reduced or other criteria defined. These technologies are also the recommended focus of United Nations International Development Organization (Jasch 2007), as it is obvious that non-production related treatment of emissions is expensive and can only be enforced by environmental laws, while production integrated prevention simultaneously reduces costs for further treatment.

4.2 Environmental Investments According to SEEA

Two types of capital expenditure are distinguished in SEEA 2003: end-of-pipe technologies and integrated investments. Expenditure on end-of-pipe technologies is used to treat, handle or dispose of emissions and wastes from production. This type of spending is normally easily identified even within the context of ancillary activity because it is usually directed towards an ‘add-on’ facility which removes, transforms or reduces emissions and discharges at the end of the production process'. Expenditure on integrated investments, also called cleaner technologies. 'These are new or modified production facilities designed so that environmental protection is an integral part of the production process, reducing or eliminating emissions and discharges and thus the need for end-of-pipe equipment' (UN SEEA 2003:215).

This distinction between treatment and prevention is only applied to investments and not to annual environmental protection expenditure. SEEA leaves open the question as to whether equipment defined as environmental investment in one year should be reported with its operating costs in subsequent years.

SEEA states 'integrated investments may result from the modification of existing equipment for the explicit purpose of reducing the output of pollutants, or from the purchase of new equipment whose purpose is both industrial and for pollution control' (UN SEEA 2003:215). In the first case, expenditure can be estimated from the cost of the modification of existing equipment. In the second, the extra cost caused by pollution control has to be estimated; that is, the cost of non-polluting or less-polluting equipment is compared with that of 'polluting or more polluting' reference equipment.'

Such estimates are difficult to make when a reference point for equipment no longer exists or new equipment presents other advantages in addition to beneficial effects on the environment. These benefits may include savings or substitution of materials and higher productivity which cannot be isolated in terms of cost. The difficulty arises because the steady integration of environmental standards in equipment and processes means that eventually it becomes impossible to identify a specific component of the expenditure as environmental.

SEEA requests that a clear distinction be made between purpose and effect. For example, in the case of environmental protection, actions undertaken for other than environmental purposes can have positive environmental effects, for example, new technologies may lead to reductions in energy use, material consumption and discharges to the environment; whereas it is conceivable that actions undertaken with an environmental protection purpose may not actually have a beneficial environmental effect. But for SEEA, only the environmental purpose criterion is applied to qualify as an environmental investment.

The CEPA definition, under which measures undertaken for cost saving reasons are excluded from environmental expenditure, is not only difficult to understand from a corporate perspective but also not well defined. Corporate accounting companies often specify a required investment payback period (e.g. 3–4 years) and allow for longer periods for environmental protection equipment. CEPA does not specify whether technology that does not provide a return on investment within a period specified, either by the firm or within SEEA, could then be classified as environmental investment (Sprenger 2007). This is not suggesting that SEEA should define payback cycles; however, the above reflection demonstrates that the criterion may not be practical.

When comparing the approach to pollution prevention and cleaner production by IFAC and SEEA, it is important to notice that SEEA does not:

- Include measures to reduce the input of materials, energy and water and increase resource efficiency
- Include measures for energy efficiency and renewable resources, as they would qualify under resource management
- Include measures which have a positive payback
- Include measures where the primary purpose is not environmental protection but resource and production efficiency
- Include measures related to reduction of the environmental impact of products

Different levels of national environmental production standards also give rise to questions. International corporations have been faced with the question: can the same technology be treated as pollution prevention in one country and state of the art in another? This has led to the situation that firms treat the same technology differently according to the particular country's environmental standards. In company projects, this has been accepted because in many countries technologies which are state of the art in the European Union are requested by environmental ministries elsewhere and thus clearly qualifies as mandatory environmental protection.

Clarification is also needed on whether reporting of investment volumes and/or annual depreciation is required. In some countries, both are required (e.g. Germany) while in others only investment volumes are necessary (e.g. Austria) with annual depreciation being estimated by the national statistical agency.

Another issue to be clarified is the point of time for recording of an investment. In many organisations, the recording for environmental statistics is undertaken by the environmental manager who has no access to the corporate accounting system and therefore tends to report investments at the project stage showing the annual cash outflow for these investments. The recording of cash outflows may significantly differ from the treatment in the financial accounting system, which records equipment only at implementation time – the point of time, when new equipment is ready for use and deprecation starts. But some countries (e.g. Romania) explicitly ask for the cash outflows in a given year even if this is only consulting services at the planning stage. This point of time conflicts with corporate wide accounting systems which flag environmental investments at the time of implementation, record the investment volume at this point of time, and list related investment grants. Depreciation in future years is thus automatically calculated.

For consistency reasons, implementation is the point-of-time for recording environmental investments and not the annual cash flow related to the current projects. This is also the point of time where investment grants related to the equipment are being posted in the related accounts. In addition, the definition of environmental investment grants in SEEA should be directly linked to the definition of environmental expenditure and not to the reasons of the agencies for granting the money.

Guidance is needed on how to treat investments that have been considered as environmentally relevant in future years. In many organisations, this data is taken directly from cost centre reports which collect depreciation, operating materials, services, and personnel for a defined cost centre. Equipment that has been defined as environmentally relevant consequently should be reported with its operating costs also in the following years for more than one accounting period.

5 Summary of Recommendations for the SEEA Revision from an Accounting Perspective

Material flow analysis builds on the concept of material and flow balancing (Ahbe et al. 1990) as introduced, for example, by Ayres (1978) and Fischer-Kowalski and Huttler (1999). The first national material flow accounts were developed at the beginning of the 1990s for Austria (Steurer 1992) and Japan (Environment Agency Japan 1992) followed by other European countries and the United States (Adriaanse et al. 1997, de Marco et al. 2001, Isacsson et al. 2000, Scasny et al. 2003, Sheerin 2002). Material flow analysis records material and energy flows and environmental protection related monetary data as a satellite system to national statistics. But, since the implementation of environmental management systems and the development of integrated cleaner technologies, satellite systems and end-of-pipe approaches are losing ground. Integrated pollution prevention is good for the environment as emissions are prevented at source. While such equipment may emit less pollution, it may also be more efficient thus requiring less material inputs and providing a beneficial result for corporate activities.

Nonetheless, how to estimate the environmental share of integrated prevention remains an open issue. The approach taken by SEEA (2003) is to allow for such measures only where the primary purpose is environmental protection and there is no economic payback. This definition in effect is in direct opposition to the merits of integrated pollution prevention. In addition, it has resulted in the perception that environmental protection is expensive resulting in a decline in corporate environmental expenditure although corporations are increasingly installing environmental management and pollution prevention systems. The solution cannot be to neglect prevention just because it is difficult to measure. The recommendations for the SEEA revision process from an accounting perspective developed here are summarised below.

Recommendations related to material flow accounting:

- Relate environmental expenditure accounting and material flow accounting, currently these two statistical assessments stand completely separate from each other.
- Apply a distinction between material inputs and product outputs.
- Define the terms materials and products and apply the definition consistently throughout the revised SEEA handbook.
- Classify material inputs into raw and auxiliary materials, which mostly become products, in opposition to operating materials.

- Clarify if and when energy and water inputs are part of material inputs.
- Clarify the related disclosure requirements in national statistical assessments.
- Separate recording of NACE code inputs of materials, water and energy.
- Separate recording of NACE code outputs of products and services.

Recommendations related to the classification of environmental costs:

- Reconsider the concept of environmental protection as a satellite system to general production and establish a more integrated environmental management approach.
- Reconsider the definition of environmental protection activities and allow for the inclusion of measures which result in cost savings, e.g. energy efficiency measures.
- Open up the SEEA approach to include measures related to reduction of the input of materials, water and energy, improving resource efficiency.
- Clarify whether water withdrawal costs are part of environmental expenditure.
- Include a criterion of actual environmental impact in addition to the 'environmental purpose criterion' for the classification of environmental protection activities.
- Separate costs for treatment and costs for prevention as a general structure for all environmental costs and not only for investments.
- Classify sub-categories of environmental expenditure according to accounting terminology.
- Assess data from management and financial accounting information systems, but not relating to potential savings or actual cash flow which is recorded differently on financial accounts due to accounting standards.
- Apply a top-down approach starting with total annual costs by financial accounts to the distribution by environmental domain affected; this requires changing the CEPA classification into a format that first distinguishes between costs for treatment and prevention, then lists the accounting categories and only, at last, classifies them by environmental domain affected.
- Preferably, apply the term *costs* to allow for more flexibility; many of the data requested have to be estimated and are thus not *expenditure* in the strict sense of financial accounting.

Recommendations related to the classification of environmental investments:

- Redraft the definition for integrated pollution prevention technologies to include measures to reduce the input of materials, energy and water and increase resource efficiency; allow for measures which have a positive financial return; allow for measures, where the primary purpose is not environmental protection, but resource and production efficiency; include measures for energy efficiency and renewable resources and measures related to reduction of the environmental impact of products.
- Record investments at the point of implementation when depreciation starts and not during the project development phase.
- Clarify whether depreciation should be recorded as part of annual costs; as depreciation regulations differ significantly from country to country many

organisations are estimating it for EMA based on average depreciation cycles, it is thus recommended to make clear that depreciation should not to be reported to statistical agencies.
- Link investments grants to the definition of environmentally relevant equipment; that means, if equipment has been considered as being 40% environmental, then 40% of a related investment grant should be recorded at the time when the grant is received, regardless of who is granting it and why.

Within a research project running from 2007 to 2009 which was funded by the Austrian Ministry for Transport, Innovation and Technology, the recommendations developed for the SEEA revision process have also been discussed with the Austrian National Statistical Institute, the Ministry of Environment and the Chamber of Commerce. These discussions have resulted in a revision of the Austrian assessment templates, explanations for the environmental expenditure assessment for the years 2006 and 2007, which took place in 2008. In addition, the recommendations have been discussed with Eurostat and within the revision process of the London Group on Environmental Accounting which has accepted the request by the UN Committee of Experts on Environmental-Economic Accounting to take a leading role in the revision of the SEEA-2003 (UN SEEA 2003).

However, full implementation of all recommendations within the SEEA revision process is not likely as SEEA itself refers and relates to several other official statistical documents which are beyond the scope of the SEEA revision and only partly address existing European regulation. This is especially so for the recommendations relating to material flow analysis which relates to the industry NACE codes and SNA.

References

Adriaanse A, Bringezu S, Hamond A, Moriguchi Y, Rodenburg E, Rogich D and Schutz H (1997) Resource Flows: The Material Base of Industrial Economies Washington DC,World Resource Institute

Ahbe S, Braunschweig A and Mueller-Wenk R (1990) Methodological Approach to Eco-Balances (Methodik fuer Ökobilanzen auf der Basis Ökologischer Optimierung) Schriftenreihe Umwelt. No. 133 Bern,Bundesamt fuer Umwelt,Wald und Landschaft (BUWAL) (available only in German)

Ayres R (1978) Resources, Environment and Economics New York,Wiley

Chiu SF and Ward J (2009) Advances in life-cycle approaches to business and resource management in the Asia-Pacific region Journal of Cleaner Production 17.14 1237–1302

de Marco O, Lagioia G and Pizzoli Mazzacane E (2001) Materials flow analysis of the Italian economy Industrial Ecology 4.2 55–70

Environment Agency Japan (1992) *Quality of the Environment in Japan 1992 White Paper* Tokyo, Ministry of the Environment Government of Japan

Environmental Protection Agency of Baden-Würthemberg (1999) *Corporate Material and Energy Flow Management, Improving Eco-Efficiency via Sustainable Reorganization* Karlsruhe (available only in German)

European Commission – Eurostat (2001) *Definitions and Guidelines for Measurement and Reporting of Company Environmental Protection Expenditure* Brussels, European Commission – Eurostat

European Commission (2001) *Recommendation 1495/2001 on theRrecognition, Measurement and Disclosure of Environmental Issues in the Annual Accounts and Annual Reports of Companies* Brussels, European Commission

European Parliament and Council (1993) *Council Regulation 93/1836/EEC Allowing Voluntary Participation by Companies in the Industrial Sector in a Community Eco-Management and Audit Scheme* Brussels, European Parliament and Council

Eurostat (2001) *Economy-Wide Material Flow Accounts and Derived Indicators: A Methodological Guide* Luxembourg, Statistical Office of the European Union

Eurostat (2002) *SERIEE – Environmental Protection Expenditure Accounts – A Compilation Guide* Luxembourg, Statistical Office of the European Union

Federal Statistical Office (2006) *Statistical Yearbook 2006* Wiesbaden (available only in German)

Fichter K, Loew T and Seidel E (1997) *Corporate Environmental Cost Accounting* Munich (available only in German)

Fichter K, Loew L, Redmann C and Strobel S (1999) *Material Flow Cost Accounting* Munich (available only in German)

Fischer-Kowalski M and Huttler W (1999) Society's metabolism: the intellectual history of materials flow analysis part II, 1970–1998 Journal of Industrial Ecology 2.4 107-136

German Environmental Protection Agency/German Environment Ministry (1995) *Eco-Controlling Manual* Munich (available only in German)

GRI (Global Reporting Initiative) (2006) *Global Reporting Guidelines* [online] [cited 05 August 2009] Available from Internet URL <http://www.globalreporting.org/ReportingFramework/ReportingFrameworkDownloads/ >

Haberl H, Jasch C, Adensam H and Gaube V (2006) *Non sustainable Trends in Austria, Forum Sustainable Austria Social Ecology* Working Papers 85 Vienna (available only in German)

Hinterberger F, Giljum S and Hammer M (2003) Material Flow Accounting and Analysis (MFA): A Valuable Tool for Analysis of Society – Nature Interrelationships SERI Background Paper No. 2 Entry prepared for *The Internet Encyclopedia of Ecological Economics* Vienna,Sustainable Europe Research Institute (SERI) (August 2003)

Isacsson A, Jonsson K, Linder I, Palm V and Wadeskog A (2000) Material Flow Accounts, DMI and DMC for Sweden 1987–199 Eurostat Working Papers No. 2/2000/B/2 Sweden,Statistics

ISO (International Standardization Organization) (1996) ISO 14001: *Environmental Management – Environmental Management Systems – Specifications With Guidance for Use* Geneva, ISO

ISO (International Standardization Organization) (2000) *ISO 1403: International Standardization Organization. Environmental Management – Environmental Performance Evaluation: Guidelines* Geneva, ISO

ISO (International Standardization Organization) (2006) *ISO 14040: International Standardization Organization. Environmental Management – Life Cycle Assessment: Principles and Frameworks* Geneva, ISO

ISO (International Standardization Organization) (2009a) *ISO 14051: CD. Environmental Management – Material Flow Cost Accounting, Committee Draft* Geneva, ISO

ISO (International Standardization Organization) (2009b) *New ISO standard will facilitate Implementation of ISO 14000 Series in 12 Languages* [online] [cited 8 March 2009] Available from Internet URL <http://www.iso.org/iso/pressrelease.htm?refid=Ref1204>

Jasch C (2001) *Environmental Management Accounting, Procedures and Principles, United Nations Division for sustainable Development, Department of Economic and Social Affairs* (United Nations publication, Sales No. 01.II.A.3) [online] [cited 1 December 2009] Available from Internet URL <http://www.ioew.at/ioew/d-ioew-set.html>

Jasch C (2007) Funding options for SMEs to finance CP projects and EST investments Vienna, UNIDO

Jasch C (2009) Environmental and Material Flow Cost Accounting – Principles and Procedures New York, Springer

Kleijn R (2001) Adding it all up: the sense and non-sense of bulk-MFA Journal of Industrial Ecology 4.2 7–8

Klöpffer W and Renner I (2008) Life-cycle based sustainability assessment of products *in* Schaltegger S, Bennett M, Burritt RL and Jasch C *Environmental Management Accounting for Cleaner Production* New York, Springer

METI (Ministry of Economy, Trade and Industry) (2007) *Guide for Material Flow Cost Accounting* Japan [online] [cited 1 December 2009] Available from Internet URL< http://www.jmac.co/jp/mfca>

Monkoe L and Jasch C (2008) Waste reduction program based on IFAC's EMA guideline in Danisco A/S *in*Schaltegger S,Bennett M,Burritt RL,Jasch CM Environmental Management Accounting for Cleaner Production New York, Springer 379–394

Pojasek R (1997) Practical pollution prevention – understanding a process with process mapping, *Pollution Prevention Review* (Summer 1997) 91–101

Savage D and Jasch C (2005) International Guidance Document: Environmental Management Accounting New York,International Federation of Accountants (IFAC)

Scasny M, Kovanda J and Hak T (2003) Material flow accounts, balances and derived indicators for the Czech Republic during the 1990s: results and recommendations for methodological improvements Ecological Economics 45.1 41–57

Sheerin C (2002) UK material flow accounting *Economic Trends* No. 583 53–61 (June 2002)

Sprenger R (2007) *Where Does Environmental Statistics Lead Is? (Die Amtliche Umweltstatistik in der Sackgasse?) Ökologisches Wirtschaften* (1.2007) 43–46 (available only in German)

Steurer A (1992) Material Flow Accounts for Austria. Social Ecology Papers 26,Vienna, IFF/Abteilung Soziale Ökologie (available only in German)

UN SNA (1993) *A System of National Accounts, Handbook on Integrated Environmental and Economic Accounting* New York, Statistical Office of the UN

UN SEEA (2003) *Handbook of National Accounting: Integrated Environmental and Economic Accounting 2003* New York, United Nations, European Commission, International Monetary Fund, OECD, World Bank

United Nations Environment Program and United Nations Industrial Development Organization (1991) *Audit and Reduction Manual for Industrial Emissions and Waste* Vienna, UNIDO and Paris, UNEP

Wernick I and Irwin F (2005) *Material Flow Accounts: A Tool for making environmental policy*, Washington DC, World Resource Institute [online] [cited 14 April 2010] Available from Internet URL <http://archive.wri.org/publication_detail.cfm?pubid=3881>

Part V
Other Issues

Chapter 12
The Benefit Side of Environmental Activities and the Connection with Company Value

Hajnalka Ván and Szilvia Gärtner

Abstract Sustainability has become one of today's most frequently used terms and is included in a growing number of documents. Before an environmental investment decision can be made, companies have to analyse not only the cost but related benefits. Benefits originating from environmental activities have higher importance. Environmental management accounting focuses much more on the cost side of the environmental activities than on benefits. Environmental benefits are often regarded as cost reduction only or some very limited opportunity for creating revenues. However, the profitability of environmental activities represents a very important opportunity for firms. As can be seen in this paper, the positive effect of an environmental activity involves more areas and is less tangible such as higher brand value, competitive advantages and lower operational costs. But how can these elements be measured and how much influence do they have on company value? This is the main question discussed.

Keywords Environmental accounting • Benefit side • Balance sheet • Company value • Valuation models

1 Introduction

Environmental costs stand in the focal point of environmental management accounting (EMA) together with their possible connection to past environmental damage and the prevention of such risks. That is why environmental costs may be classified into

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the following categories: waste and emission treatment, prevention and environmental management, material purchase value of non-product output, and processing costs of non-product output. In contrast, the benefit side is often limited to accounting for environmental revenues, subsidies and other earnings (UNDSD 2001, Csutora and Kerekes 2004, Ditz et al. 1995). In the contemporary accounting system, the value of a company is shown in the balance sheet. The two sides of the balance sheet are assets and liabilities; environmental issues appear on both sides of the balance sheet. Assets can be fixed or current. Liabilities contain provisions and accounts payable. Assets can be either fixed assets, such as the capitalisation of environment-related investment costs, or current assets, such as the major potential collector of stocks related to the environment. Any change in inputs/outputs of the material flows would certainly influence the level and composition of stocks. On the liabilities side, provisions and accounts payable may hide environment related information (UNDSD 2001). Provisions may embrace uncertain liabilities, as determined by the law, and accounts payable related to environmental issues. The present chapter seeks an answer to the following questions:

- How can the benefits of environmental projects be understood?
- Do benefits take the same place on the balance sheet as costs?
- Do environmental benefits contribute to shareholder value?
- How is it possible to evaluate environmental benefits?

2 Benefits of Environmental Activities

The review of relevant literature demonstrates that the benefit side is mentioned only in a few cases. However, management needs to assess the potential costs and benefits of every project to make the right priorities (Schaltegger and Synnestvedt 2002:344). Related concepts include the idea of Schaltegger and Burritt (2000) who first defined environmentally induced benefits. 'Such benefits include environmentally induced additional revenues [...] and reduced costs' (Schaltegger and Burritt 2000:94). This literature focuses mostly on environmentally induced costs putting little emphasis on environmental benefits. Benefits consist of direct and indirect elements. Direct revenues include measurable factors like gains from sales of recyclables, increased volume of sales and higher prices of sold products. Indirect elements are less tangible, for example image and increased customer satisfaction.

The approach of the United Nations Division for Sustainable Development (UNDSD) (2001) is similar to the above-mentioned concept. It distinguishes between subsidies, awards and other earnings. The first pillar consists of tangible direct effects while the second comprises less tangible ones. However, focus falls on the cost side. In Japan, the government requires submission of a report on environmental effects, benefits and costs. Besides 'environmental conservation cost', there is a distinction between 'environmental conservation benefit' and 'economic benefit associated with environmental conservation activities' (Ministry of the Environment Japan 2005:3). Environmental conservation benefit is measured in physical units like prevention and reduction. Economic benefit associated with environmental conservation activities means profit for a company and is measured in financial terms. It differentiates between actual and estimated benefits but its basic emphasis is on measurement. The last concept to be mentioned here is conceived by Csutora (2007). Her paper combines environmental benefits with the evaluation of natural resources. Its main innovation lies in displaying less tangible elements and providing a possible measuring method. In summary, EMA concentrates on the cost side and benefits, and in most cases, appears as an element deriving from cost savings.

Environmental benefits of a company's business operations can have positive effects internally within the business and on the external environment of customers or the natural environment. In the present chapter, emphasis falls on the internal benefits created by the company's business operations. The environmental internal business benefit used in this context is similar to the economic benefit associated with environmental conservation activities as defined by the Japanese Ministry and the environmentally induced additional revenues introduced by Schaltegger and Burritt (2000). However, environmental internal business benefit will be examined here at the micro level from the company's point of view instead of staying at the broader macro level.

The evaluation of environmental internal business benefits needs to be explored in greater depth. A part of these benefits can be evaluated by using monetary and/or physical value. However, the majority of the benefits are less tangible and less predictable or are immeasurable. The basic concept of environmental benefits differentiates the tangible and less tangible benefits of environmental activities. As long as environmental benefits are directly linked to specific cost saving outcomes, in an environmental project they can be easily calculated (Schaltegger and Burritt 2000, Ministry of the Environment Japan 2005). Estimating and measuring positive outcomes can easily run into difficulties in case of less tangible benefits such as attraction of customers, good image or good relationship with authorities (Csutora 2007, Beer and Friend 2006).

Estimating less tangible benefits is problematic in general. For instance, it is clearly visible in case of decisions made on information technology investments (Carr 2003, Roztocki and Weistroffer 2005). The question of how much to invest in information technology while keeping the investment profitable is hard to answer. It is important to see that it is easier to calculate the cost of an information technology project than its benefits. The benefits including increasing earnings, cost savings and intangible elements, are not delivered by a single division but through the overall efficiency improvement of the business processes which increases the profitability and the company value (Fehér 2008).

2.1 The Monetary Category of Environmental Benefits

Accounting refers to the measurement of events in economic terms as well as summarising and reporting them in the form of financial statements for stakeholder use. Reporting is the ultimate function of accounting. The input-output process represents the main business recycling process in a company (Chikán 2002).

The main aim of a company is to generate products which satisfy consumer needs. In Porter's (1985) value chain, there are nine activities which illustrate the total company process and create market value. The model consist of five primary activities (inbound logistics, operations, outbound logistics, marketing, and sales and services) and four support activities (infrastructure, human resource management, technology development, and procurement) (Chikán and Demeter 1993).

In order to be able to grasp environmental benefit opportunities, the following categories will be used hereafter: process, product, other, and financial. Inbound logistics and operations are in the process category while outbound logistics is in the product category. The third category consists of the four support activities and two categories from primary activity, marketing, and service. The fourth category is the financial as such elements exist in the background of every business process with profitability as an ultimate goal. In the next section, these categories are used for arranging basic benefits for further evaluation.

2.2 Environmental Benefits – Connection with the Accounting System

The accounting system has to give information about overall business processes. Financial accounting gives information in the annual financial statements which consists of the balance sheet and income statement as well as cash flow. External stakeholders get information about the environmental activities from the financial statements. The cost side of environmental activities is elaborated in most cases in environmental management accounting, but the benefit side is less emphasised. This section focuses on the appearance of environmental benefits in the income statement rather than the balance sheet. The main output documents of financial accounting are the income statement and the balance sheet.

This section shows the positive outcome of an environmental activity of the business. Conventional accounting is not sensitive to these activities and so they are hidden in the balance sheet. In an earlier section, it was explained that activities of the value chain were arranged in four support categories which were considered the basis for the arrangement of benefits. The benefits consist of earnings, savings and intangible benefits. The intention is not to aggregate a complete list of the categories and differentiate between earnings, cost savings and intangible elements, but to give some examples to help differentiate among the four categories. Accordingly, these benefit categories have been collected in a scheme arranged in line with the following four categories: process benefits, product benefits, financial benefits and other benefits (as based on Porter 1985, Schaltegger and Wagner 2006, Figge et al. 2002).

Process benefits originate from the realignment of the process within the company. Product benefits can be revealed through stock analyses. Financial benefits indicate positive effects on the fiscal side, although they are not easy to identify on the balance sheet. The other category of benefits contains less tangible benefits. Tangible, as well as less tangible benefits can be organised along the lines of these four categories. Furthermore, it is possible to draw up a summary table (Table 12.1)

Table 12.1 Benefits from environmental activities – connection with the balance sheet

Benefits	Quantitative	On the balance sheet	Qualitative	On the balance sheet
Financial	Earnings from the sale of materials for reuse and recycling	Retained earnings	Lower level of human workforce cost	Retained earnings
	Financial subsidies, awards	Retained earnings		
	Lower level of environmental fees, taxes, charges (reduction of emission and discharges)	Retained earnings		
	Provision/insurance for damages	Provisions, retained earnings		
Process	Effective resource utilisation (e.g. recyclable waste)	Stocks	More rational decision-making	Hidden in retained earnings
	Environmental research and development	Intangible assets/hidden in retained earnings	Environmental management system	Hidden in retained earnings
Product	Sales of environmental friendly products	Retained earnings	Multiplier effect	Retained earnings
Other				
Human resources			Healthier workforce	Hidden in retained earnings
			Better employee morale	
Company			Symbolic awards	
			Marketing advantages	
			Reduced risks, accidents	
			Damages avoided through insurance	
Surroundings			Green image	Fixed assets
			Better reputation	Fixed assets
			Fair evaluation	Hidden in retained earnings
			Good customer relations	
			Good relationship with authorities	
			Good relationship with competitors	
			Better public trust and confidence	

along these dimensions (tangible-intangible, process, product, financial and other benefits).

First, financial benefits contain the cases that have an effect on financial processes. In a well-established management accounting system it is easy to assess benefits. The immediate cash flow earnings are the first to be reviewed in this category. Examples include benefits deriving from recycling materials sold or subsidies for a wastewater treatment plant. The other benefits focus on savings, such as the lower level of taxes and fees, because of environmentally friendly technology, or lower pollution costs. Next, the provisions and insurance elements of financial benefits are analysed. The above-mentioned benefits have positive effects on financial processes, while provisions and insurance have negative effects. It is apparent that the financial benefits include generally measurable elements, but reduction of employee cost because of better working conditions is less easy to measure (Earnhart and Lizal 2007). Better working conditions means lower turnover, which reduces training expenses or saves coaching time. However, this factor is only estimated without being specifically measurable. On the one hand, financial benefits on the balance sheet can appear in an indirect way, namely in the profit and loss account as increased revenues, or decreased expenditures. On the other hand, they can appear directly in the provisions although they are not stock but flow indicators.

The realignment of the production/service providing process can exercise a positive effect on the firm. Innovation, environmental management systems and environmental realignment can be classified in this category. The tangible component can be ensured through better use of materials, for example lower amounts of materials or energy produced in-house. Effective resource use can mean decreasing material needs and lower levels of stock in the balance sheet. In addition, lower levels of costs in the profit and loss statement results in increased retained earnings. This exercises potentially positive effects on the price of products. The less tangible part is the information provided by the environmental management system which can generate more rational decision-making, reliability and flexibility. These elements have no direct effect on value creation processes but boost the productivity of capital and labour. One similar element is environmental research and development which can appear among the intangible assets in the balance sheet but it has an effect on the whole company by increasing profitability and shareholder value. Process benefits on the balance sheet are visible through improving stock figures through material flow accounting and increasing or decreasing retained earnings as influenced by revenues and costs. Process benefits are also mentioned in the literature in many cases.

Product benefits are attached to the goods, for example they contain benefits from the sale of environmentally friendly products such as earnings. The effect is in the profit and loss statement and appears in the balance sheet via retained earnings. Furthermore, it can also boost the sale of other products, thus exercising a multiplier effect.

As Table 12.1 shows, other benefits can contain more elements than those in the three previously mentioned categories. Within this category, benefits related to human resources, the company and surroundings can be distinguished. Better working conditions, such as fair wages, safe working environment, serve to make the workforce more reliable and efficient. These elements can increase productivity via the reduced cost of training of new employees. Following the human benefits, it is appropriate to review the benefits created by the company. For example, a company may receive awards because of its environmental activities which may lead to fairer evaluation. Insurance can decrease the number of accidents which increases public trust. The environmental surroundings can lead to good and improving relationship with the stakeholders. The trust of customers, authorities or competitors can also improve. These elements are hidden in the balance sheet, in the form of fixed assets like goodwill or retained earnings. In many cases, it is not easy for a company to make an estimate; however, it can gain from positive effects like flexibility in operations, quicker processes in terms of administration and permits.

The scheme described above explains that benefits are hidden in the balance sheet. A fine-tuned, detailed-orientated system is necessary to assess these benefits. In conventional accounting, the balance sheet and the profit and loss statement cannot provide adequate information on factors such as environmental activities (Schaltegger and Burritt 2000, Rappaport 1998, Schaltegger and Wagner 2006). How is it possible to display these elements? Modern valuation methods may represent a more appropriate solution, while, according to the conventional approach, environmental protection has no positive effect on productivity and profitability. Companies have to consider the interest of stakeholders. According to the modern approach, the decision-making process has to take into account not only cost but also benefits. Shareholder value is close to this modern approach, that is, the main goal of a company is to build shareholder value while complying with the law (Rappaport 1998). This model ensures satisfaction of the long-term interest of stakeholders and includes methods like accounting-based approaches, discounted cash flow models, relative valuation models, contingent claim valuation models, and assets-based valuation (Damodaran 2002, Copeland et al. 1994). Chousa and Castro (2006) present a new and complex method for the financial analysis of sustainability. They elaborated this model to help uncover a company's true financial, environmental and social situation (Chousa and Castro 2006). These approaches can demonstrate environmental benefits too but since some of the approaches are heavily intangible, certain evaluation models are not suitable for this task. Before examining how environmental benefits can contribute to company value, the next section concentrates on the value drivers of benefits and the neoclassical evaluation methods for their estimation.

3 Methods for the Evaluation of Environmental Benefits

In the previous sections environmental benefits were introduced. Next is the question of how to measure these benefits.

3.1 Value Drivers and Environmental Benefits

First, value drivers must be defined. A value driver is an activity that contains positive effects for the company that originate from environmental activities. The following six value drivers of sustainability create the basis for the evaluation method (Sustainability, IFC and Ethos Institute 2001, Schaltegger and Figge 2000):

- Costs saved;
- Increased revenues;
- Reduced risks;
- Reputation building;
- Human and natural capital; and
- Improved access to capital.

A relationship exists between value drivers and environmental benefits which influence the value drivers (Table 12.1). What are the connections between them?

A business can reduce its costs by making environmental improvements which have an impact on the financial processes. Some savings derive from effective resource utilisation including less energy and materials. Others lower the level of environmental fees and taxes caused by the environmental activities. Cleaner production measures, for example the sale of waste, can involve lower levels of environmental fees or penalties which may contribute to increased brand value. The indirect benefits originate from the substitution costs of marketing; for example winning an award can save the company considerable marketing cost since such recognition offers free advertisement and this reputation can contribute to improved image and customer confidence. For major events, the costs of insurance do not give the real value. The value of avoided damage is the applicable valuation method. This value depends on the attitude-to-risk of the company managers so the management willingness to pay for preventing an accident can be a good estimate of the value of safer operations. Above all, good relationship with stakeholders has positive effects. For example permitting may become easier and quicker by regulatory authorities. The benefits from better working conditions, like a clean and safe working environment, are indirect flows too, while education benefits also have positive effects on employee morale and productivity. Better working conditions can contribute to higher productivity, training cost savings, lower operating risk, and a stable workforce.

Increased revenues primarily originate from sales. How is it possible to increase sales? There are many alternatives. First, environmental research and development can contribute to sales of new products which can mean gaining a market niche, and associated increased earnings. The sale of waste contributes directly to earnings. Effective resource utilisation and a lower level of production costs can stimulate demand which translates into higher sales figures. Furthermore, environmentally friendly products can boost the sales of other, perhaps non-environmental, products as a better image can flow through to general customers and lead to increased revenues. Rational management and the environmental management system can decrease operational risks and provide long-term opportunities.

Good relations with stakeholders can reduce the risks of the company and thus provisions and insurance (Lankoski 2006, Salzman et al. 2005). Established decision-making and better working conditions may result in the reduction of the risk profile and ensure the long term operation. The theoretical background is that present benefits are more valuable and costs more painful than future benefits and the cost in cash flow calculations.

The company's environmental and social performance exercises a positive effect on brand value and reputation. Awards and risk reduction measures can increase reputation, leading to better image and confidence. Good relations with authorities can result in a lower level of operating cost (Lankoski 2006, Steger 2006), and flexible, quicker operational processes. Good stakeholder relations can increase confidence, fair evaluation and good reputation. Human capital can improve because of better working conditions and risk reduction. An improved access to capital may originate from better relations with authorities and risk reduction can create an opportunity to develop ethical funds. The opportunity to access financial capital can increase because of a good reputation. The company may be invested in by an ethical investment fund because of strong environmental performance or banks provide easier credit to the company.

It can be seen that environmental benefits are connected with the value drivers which affect shareholder value. After the connections are demonstrated, measurement remains the major question. Measurement of some environmental benefits (Table 12.2) is simple, for example earnings from the sale of waste, or sales of environmental products. Other elements are not so easy to measure, but a well-established management accounting system can provide reasonable data for cost reduction via environmental research and development or lower environmental fees and taxes. As the Table 12.2 shows, calculation of the major part of environmental benefits is complex. Some natural resource evaluation methods can be applied for estimating environmental benefits at the company level.

3.2 Benefits and Neoclassical Evaluation Methods

Different models exist for the evaluation of environmental benefits. This section introduces the notion of evaluation of natural resources in connection with environmental benefits. It applies neoclassical valuation methods, since these provide valuations for making individual economic choices. Thus, economic value is measured by what someone is willing to give up for goods and services in order to obtain another goods or services (King and Mazzotta 2000, Marjainé 2005).

In order to proceed, the concept of value must be defined. Two main categories of values can be distinguished: use values and non-use values. Use values originate from the actual use of natural capital (Constanza and Daily 1992). In addition, they contain option values – this means that people do not use natural resources currently, but they promote resource preservation in the interest of potential future use (Constanza et al. 1989). Non-use values refer to the phenomenon that people

Table 12.2 Value drivers and environmental benefits and measurement

Value drivers Environmental benefits	Value drivers/benefits	Increased revenue/ customer attraction	Cost reduction and efficiency improvement	Risk profile	Reputation and brand value	Human capital	Access to capital
Financial	Earnings from the sale of materials for reuse and recycling	Sales					
	Financial subsidies, awards		Substitution cost of marketing		Good image		
	Lower level of environmental fees, taxes, charges		Cost reduction		Good image		
	Provision/insurance for damages		Hidden cost savings	Lower risk			
	Lower level of human workforce costs		Cost reduction				
Process	Effective resource utilisation	Contribution to sales	Cost reduction				
	Environmental research and development	New product	Reduced cost or new processes, savings				
	More rational decision-making		Contribution to efficiency improvement	Lower risk			
	Environmental management system		Cost reduction	Lower risk			

Value drivers							
Environmental benefits	Value drivers/benefits	Increased revenue/ customer attraction	Cost reduction and efficiency improvement	Risk profile	Reputation and brand value	Human capital	Access to capital
Product	Sales of environmentally friendly products	Sales			Good image		
	Multiplier effect	Sales					
Other	Better working conditions	Output efficiency	Reduced turnover cost, higher efficiency	Lower risk		Stable workforce	
	Symbolic awards		Lower level of marketing cost (substitution cost)		Goodwill		Capital cost reduction through ethical funds
	Marketing advantages		Substitution cost of marketing				
	Risk reduction		Cost increase, but contingent cost reduction	Reduction in costs of accidents	Goodwill		Better opportunity for credit
	Green image	Sales			Goodwill		
	Better reputation	Sales			Goodwill		
	Good customer relations	Sales			Good image		
	Good relationship with authorities		Reduced cost of operation				
	Good relationship with competitors		Lower incidental expenses	Lower risk			
	Better public trust and confidence	Sales			Good image		

attribute value to a natural resource without reference to its use. Total economic value consists of the sum of use and non-use values of goods and services (King and Mazzotta 2000, Marjainé 2005, Pearce 2002, Turner 2001, Munasinghe 1993).

Within the neoclassical evaluation method, the following categories can be distinguished (King and Mazzotta 2000):

- Revealed willingness to pay
- Imputed willingness to pay
- Expressed willingness to pay

The basis of the first category is market price, that is, consumer and producer surplus constitute value as in the case of other market goods. Value can also be calculated in an indirect way, for example the value of natural resources that are used as input may be estimated by their contribution to the profits associated with the final good. The value of non-market goods can be established by considering the price that people are willing to pay for them. Potential measurement methods include market price, productivity, hedonic pricing, and travel cost method. The category of imputed willingness to pay is based on what people are willing to pay or the cost that they are willing to take in order to avoid negative effects in the event that services deteriorate. These methods are: damage cost avoided, replacement cost, and substitute cost methods. The third category contains the evaluation of non-marketed goods; here surveys are applied to ask people what they are willing to pay. Contingent valuation and contingent choice methods fall into this measurement category. After discussing the different evaluation methods, the next section moves on to describe the methods relevant to environmental benefits.

3.2.1 Productivity Method

This method evaluates natural resources based on how they contribute to the production of market goods. Changes in quality or quantity influence production costs. The value of natural capital may be estimated based on the extent of the gain deriving from such natural capital decreases if it is damaged because of some external effect (Marjainé 2005).

The productivity method estimates the value of environmental measures by the productivity improvement reached, for example greater training of human resources can exercise a positive effect on output efficiency, for example through a lower level of waste. Another instance may be managerial qualities that have longer-term strategic effects heavily influencing the cash flow (Csutora 2007, Csutora and dePalma 2008, Schaltegger and Synnestvedt 2002, Wagner and Schaltegger 2004). The productivity method is widely applicable. An example is when estimating losses avoided by insurance. The method is also relevant when examining how environmental management systems can contribute to lower risks or to cost reduction. However, the fact that resources used as input are the focal point of this method is problematic, as it makes the approach rather complicated. This method is limited to valuing only the inputs in production. The method is problematic if the natural resources or the price of other inputs change. The productivity method can also be used to assess the shareholder value of a company. Within the discounted cash flow models, it belongs to the excess return approach. The method serves to define the present value of excess returns expected from investments.

3.2.2 Travel Cost Method

With the travel cost method, assessing demand for, and value of, natural resources is based on past behaviour (Marjainé 2005). According to its basic assumption, 'time is value, travelling is costly and cost increases with distance' (Randall 1994:88). The traveller's income constitutes the basis for the value of time. The higher the income involved, the more valuable becomes the environmental benefit (Csutora 2007).

3.2.3 Replacement Costs

This method offers a tool for estimating the replacement of natural resources. It approximates the value of replacement as the cost of the best alternative opportunity saved (Marjainé 2005). For example, better working conditions might result in a decreased turnover of employees. The value of such decreased turnover can be estimated by the saved replacement and training cost for new entrants. Another example is the value of an investment in an environmentally friendly filter that is measurable by penalties and fees saved (Csutora 2007). Potential problems related to this method include that the value can be higher or lower than the original value (over- or under-estimation). This approach also occurs among company valuation models, and is similar to the above-mentioned one. Furthermore, it is also associated with Tobin's Q indicator which is used for the evaluation of intangible assets (Bouteiller 2000).

3.2.4 Damage Cost Avoided

This approach is based on the costs of avoiding damages arising from the loss of services (King and Mazzotta 2000). When the natural environment is influenced by a negative effect, it will lead to deterioration in the value of the services provided by the natural environment itself. If this proves to be an important factor, then various measures will be made and the costs of these measures provide the value of the natural resource (Marjainé 2005). It serves to assess avoided potential damages, for example involving the public sphere in the preliminary phase of an investment planning process, and is associated with high cost – management time or organising meetings. Furthermore, its effects may also include avoiding the damage deriving from potential demonstrations that can cause objections or postpone deadlines (Csutora 2007). Either the cost of insurance or that of provisions can indicate the associated value. Problematic issues related to this method include questions such as the situations in which the insurance is necessary or the alternatives that can be selected and the amount associated with it. Consequently, this tool only qualifies as a very rough indicator of value.

3.2.5 Substitute Goods

Non-marketable products without market value can be estimated by a similar, substitute product with market value (Marjainé 2005). A factory may produce much waste. The value of recycled waste can be predicted on this base. The value of the recycled waste can be priced as the value of the new input.

3.2.6 Contingent Valuation Method

This method uses survey questions to indicate people's preference for goods and its main objective is in finding out how much they are willing to pay for specific improvements or to preserve the environment. If the goods have no market, the questionnaire applies a hypothetical market (Mitchell and Carson 1989).

Contingent valuation is a widely used method in resource economics to measure how people contribute to environmental problems. It is subjective by nature and serves to assess managers' risk acceptance as well as how much they are willing to pay for risk avoidance. Huge risks threatening the survival of a business are usually covered by different types of insurance (Csutora 2007). Problems may arise when individuals are misinformed or their preferences may not adequately incorporate social fairness, ecological sustainability and other important goals (Constanza et al. 1998:8, Munasinghe 1993). Option value is also relevant; it represents the value of leaving opportunities open. For example, a company may decide to invest in exploring a new natural gas field even if extraction costs are too high there, since the resource lies too deep to be extracted in a profitable way. As prices change, the situation might become more favourable from a business point of view, so even explored but not profitable resources can have a value attributed to them and the area is worth being explored as long as this option value remains higher than the associated exploration cost (Csutora 2007, Munasinghe 1993). Closely associated with the contingent valuation model, this value can provide an ideal basis for company valuation methods.

4 Case Study on the Contribution of Environmental Benefits to Shareholder Value

In the interest of a better understanding of valuation methods, a small empirical example is introduced. The key figures and results are provided but the detailed method is not explained. An existing factory undertaking business in the automotive industry is the focus of the case study. The basic mission of the company is to use the least possible energy and materials for production supported by an environmental accounting system. The real benefits and costs of its environmental activity are managed separately from the other benefits and costs.

The following environmental cost categories exist:

1. The costs of the treatment of in-house environmental effects of production such as: costs of pollution treatment and prevention, the costs of effective energy usage;
2. Environmental costs during the product life-cycle: additional costs of green procurement, the insurance costs of the environmentally friendly products and services, the packaging treatment and recycling costs at the end of the product life-cycle;
3. Management costs includes wages and salaries, costs of the environmental training of staff, expenses of the environmental department as well as the costs of the environmental effect measuring and registration;
4. Costs of research and development activity: development of environmentally friendly products, as well as additional costs, which are coming from the environmental conscious design activity;
5. Social activity costs: financial assistance for non-government organisations; costs of environmental communication and gardening costs (an external company undertakes the gardening) are included; and
6. Expenses of environmental damage: re-cultivation and damage prevention, the costs of the proceeds taken because of environmental damage and penalties payable, with this category not creating any added value for the company and can never be refunded; hence, the most important result for improved environmental performance is to avoid these costs.

Having summarised the costs, the benefits of the environmental activities can examined by dividing them into three categories:

1. Returns of business operation: earnings from sale of renewable energy resources, recycled materials and environmentally friendly products;
2. Cost saving and cost reduction – this is the most significant group of environmental measurements. Included here are the savings from energy and material efficiency as well as the savings from energy recycling; and
3. Estimated benefits from high environmental performance: benefits from the communication of outstanding environmental performance, for example appearance on television or articles about environmental prize winning, which improve the company image and can be considered as a 'publicity free of charge'; to this category belong the benefits coming from lower risk because of high environmental performance levels (lower capital cost); these benefits are estimated because they are not accompanied by real incomes or savings their value can be only estimated.

As the value drivers transmit the effects of company decisions to company value, it is important to grasp the value drivers in which the costs and benefits of

Table 12.3 The effects of the environmental measurements on the value drivers

Value creating factors	Measurements				
	Insurance of environmentally friendly products	Pollution abatement and prevention	Energy saving	Waste and material recycling	Control. management
Operation					
Growth rate of revenue (g)					
Net operating profit less adjusted taxes					
Corporation tax (T)					
Investment					
Fixed working capital (dIC)					
Fixed assets (dIC)					
Finance					
Capital cost (WACC)					
Value increase period (n)					

the environmental measurements appear. In Table 12.3, measurements are divided into five groups. The relation between the measurement and the value drivers are shown in light gray.

1. *Introduction of environmentally friendly products.* If applied successfully, this can increase revenues. Developing this kind of product represents higher costs and can have effects on the operation income. This strategy can have an effect on the 'value increasing period' as the environmental friendly product may provide a competitive advantage and make it possible to create extra profits for a long time.
2. *Pollution abatement and prevention.* These measurements can affect the operational income, fixed working capital and fixed assets. For example, in the interest of sewage treatment it is needed to install equipment in contrast accidents and penalties payable can decrease which can mitigate the risk.
3. *Energy saving.* This reduces the operational costs and risks as well. Since the changes of energy prices can be considered as a systematic risk, energy saving can reduce capital cost through β.
4. *Waste and material recycling.* These reduce the material costs and the necessity of fixed working capital, as there will be an opportunity for the rundown of inventories.
5. *Management control.* This means the implementation and operation of the environmental management system. For most parts, it consists of staff costs and influences operational income. At the same time, an effectively operating environmental management system can result in continuous monitoring and a decrease in environmental risks, as well as having a positive effect on capital.

The evaluation of the company can be carried out on this basis (Rappaport 1998). The focus is not on the calculation process, which is considerable, but on the change in company value if environmental protection is not considered.

The result is that the value of the factory is €263,512. The next step is to investigate what kind of effect the non-performance of the different environmental related measurements has on this value.

1. *The material cost and the increase in the fixed working capital.*
   If the factory does not deal with environmental protection, the costs and benefits relating to it will not occur. The primary condition of the benefits is the appearance of the cost; therefore, based on the difference between the income and expenses, the company value is calculated with the increased cost. The difference between the income and expenses is a positive number, which means that the costs resulting from the environmental activity have more significant benefits. If the environmental activity is not performed, the same cost increase would appear; therefore, the amounts will be accounted for with the proportional cost increase together every year. Considering the additional fixed working capital in the same way (customers and inventories), since the environmental investments will be cancelled, the value of the tangible assets would decrease every year. Resulting from these changes, the company value is €257,155. In this case, the environmental measurements contributed to the company value with €6,357 which could appear small compared with the total sum. This result shows the benefit from taking up the environmental protection.
2. *Increase of capital cost.*
   Where the environmental performance of a company is low and risks involved are high (serious accidents, breakdown, environmental pollution and penalties, energy and material waster operation), the Weighted Average Cost of Capital (WACC) can be raised through a higher *b*, or through the higher rate of interest by credit granting institutions. To estimate this effect is quite difficult, but in this case because of the high environmental performance the factory reduces the cost of credit by 1%. Performing the evaluation again, the result is €243, 352 which means an additional decrease in the company value of €13,802.
3. *Decrease in the increasing rate of the revenues.*
   Providing environmentally friendly products produced by environmentally friendly technology for customers has a positive effect on the revenues. It ensures a good image and a competitive edge against competitors. In this case, this contributes to an increasing rate of revenues by 1% each year. If this 1% point will be subtracted every year, the effect will be quite dramatic, because the value of the factory will be €193,367, which means a €49,986 decline. This effect could be similar but more significant if it entails not only the decline in the revenues but the loss of competitive advantage.

In the adverse case, when environmental protection is left out of consideration a significant decrease in the company value can be calculated. All this does not provide a full scale evaluation of the company, as some elements of environmental benefits are not included in the model.

5 Summary

The main aim of the present chapter was to emphasise the importance of environmental benefits. In the first part, environmental benefits were introduced together with the associated approach to accounting. These methods present various problems since conventional accounting systems face certain limitations, although environmental benefits obviously exercise a positive effect on companies and contribute to their value. Modern valuation methods can overcome these difficulties. The following section dealt with the question of how environmental benefits can contribute to company value. The chapter also examined how these elements can be estimated and how they are related to company value. However, evaluations must be carried out carefully since estimation is not always accurate. Furthermore, the benefits of an environmental project can appear on the local, regional or global level instead of definitely occurring at the place where environmental benefits are valued. It can be concluded that environmental benefits are relevant in this relation, since they create hidden positive effects for companies. As a next possible step, a mathematical justification of this model may be developed.

References

Beer P and Friend F (2006) Environmental accounting: a management tool for enhancing corporate environmental and economic performance *Ecological Economics* 58.3 548–560

Bouteiller C (2000) The evaluation of intangibles: advocating for an option based approach Paper presented at the *Alternative Perspectives on Finance and Accounting Conference* APFAC, Hamburg (4–6 August 2000)

Carr NG (2003) IT doesn't matter *Harvard Business Review* 81.5 41–59

Chikán A (2002) *Vállalatgazdaságtan* Budapest, AULA

Chikán A and Demeter K (1993) *Értékteremtő Folyamatok Menedzsmentje* Budapest, AULA

Chousa JP and Castro NR (2006) A model of financial analysis at the service of sustainability *in* Schaltegger S and Wagner M *Managing the Business Case for Sustainability: The Integration of Social, Environmental and Economic Performance* Sheffield, Greenleaf 127–145

Constanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Linburg K, Naeem S, O'Neill VR, Paruelo J, Raskin RG, Sutton P and van den Belt M (1998) The value of the Word's ecosystem services and natural capital *Ecological Economic* 25.1 3–15

Constanza R, Farber SC and Maxwell J (1989) Valuation and management of wetlands ecosystems *Ecological Economics* 1.4 335–361

Constanza R and Daily HE (1992) Natural capital and sustainable development *Conservation Biology* 6.1 37–46

Copeland T, Koller T and Murrin J (1994) *Valuation Measuring and Managing the Value of Companies* New York, Wiley

Csutora M (2007) EMA – estimating the benefit side *EMAN Conference* Helsinki, EMAN

Csutora M and dePalma R (2008) Using EMA to benchmark environmental costs – theory and experience from four countries through the UNIDO TEST Project *in* Schaltegger S, Bennett M, Burritt RL and Jasch C *Environmental Management Accounting for Cleaner Production* Amsterdam, Springer

Csutora M and Kerekes S (2004) *A Környezetbarát Vállalatirányítás Eszközei* Budapest, KJK-KERSZÖV

Damodaran A (2002) *Investment Valuation, Tools and Techniques for Determining the Value of Any Assets* New York, Wiley

Ditz D, Ranganathan J and Banks RD (1995) *Green Ledgers: Case Studies in Corporate Environmental Accounting* Baltimore, World Resources Institute

Earnhart D and Lizal L (2007) *Does Better Environmental Performance Affect Revenues, Cost, or Both? Evidence from a Transition Economy* William Davidson Institute Working Paper Series No. 856 Michigan, William Davidson Institute

Fehér P (2008) *Informatikai Beruházások Pénzügyi Értékelése* Budapest, Budapest Corvinus University

Figge F, Hahn T, Schaltegger S and Wagner M (2002) The sustainability balance scorecard-linking sustainability management to business strategy *Business Strategy and the Environment* 11.5 269–284

King MD and Mazzotta JM (2000) *Ecosystem Valuation* [online] [cited 28 December 2010] Available from Internet URL <www.ecosystemvaluation.org>

Lankoski L (2006) Environmental and economic performance in Schaltegger S and Wagner M *Managing the Business Case for Sustainability: The Integration of Social, Environmental and Economic Performance* Sheffield, Greenleaf 32–46

Marjainé Sz.. Sz. (2005) *A Természetvédelemben Alkalmazható Közgazdasági Értékelési Módszerek* Budapest, KVM Természetvédelmi Hivatal

Ministry of the Environment Japan (2005) *Environmental Accounting Guidelines* Japan, Ministry of the Environment Japan

Mitchell RC and Carson TR (1989) *Using Surveys to Value Public Goods: The Contingent Valuation Method* Washington DC, Resources for the Future

Munasinghe M (1993) *Environmental Economics and Sustainable Development* Washington DC World Bank

Pearce D (2002) An intellectual history of environmental economics *Annual Review of Energy and the Environment* 27.1 57–81

Porter M (1985), *Competitive Advantage: Creating and Sustaining Superior Performance* New York, The Free Press

Randall A (1994) A difficulty with the travel cost method *Land Economics* 70.1 88-96

Rappaport A (1998) *Creating Shareholder Value – A Guide for Managers and Investors* New York, The Free Press

Roztocki N and Weistroffer HR (2005) Evaluating information technology investments: a fuzzy activity-based costing approach *Journal of Information Science and Technology* 2.4 30–43

Salzman O, Ionescu-Somers A and Steger U (2005) The business case for corporate sustainability: literature review and research option *European Management Journal* 23.1 27–36

Schaltegger S and Burritt R (2000) *Contemporary Environmental Accounting Issues, Concepts and Practice* Sheffield, Greenleaf Publishing

Schaltegger S and Figge F (2000) Environmental shareholder value: economic success with Corporate Environmental Management *Eco-Management and Auditing* 7.1 29–42

Schaltegger S and Synnestvedt T (2002) The link between 'green' and economic success: environmental management as the crucial trigger between environmental and economic performance *Journal of Environmental Management* 65.4 339–346

Schaltegger S and Wagner M (2006) Managing and measuring the business case for sustainability: capturing the relationship between sustainability performance, business competitiveness and economic performance in Schaltegger S and Wagner M Managingthe Business Case for Sustainability: The Integration of Social, Environmental and Economic Performance. Sheffield, Greenleaf 1–27

Sustainability, IFC and Ethos Institute (2001) *Developing Value the Business Case for Sustainability in Emerging Markets* London, Sustainability Ltd.

Steger U (2006) Building a business case for corporate sustainability in Schaltegger S and Wagner M *Managing the Business Case for Sustainability: The Integration of Social, Environmental and Economic Performance* Sheffield, Greenleaf 412–443

Turner KR (2001) The place of economic values in environmental valuation in Bateman IJ and Willis KG *Valuing Environmental Preferences, Theory and Practice of the Contingent Valuation, Method in US, EU and Developing Countries* New York, Oxford University Press 17–41
UNDSD (2001) *Environmental Management Accounting Procedures and Principles* New York, UNDSD
Wagner M and Schaltegger S (2004) The effect of corporate environmental strategy choice and environmental performance on competitiveness and economic performance: an empirical study of EU manufacturing *European Management Journal* 22.5 557–572

Chapter 13
Implementation of Water Framework Directive Obligations in Hungary: Estimating Benefits of Development Activities in Two Pilot Areas

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Abstract Implementation of the *Water Framework Directive* entails several tasks for European Union member states including Hungary. One important issue is the estimation of economic benefits resulting from improvement of water quality and condition. Contingent valuation has been used in Hungary in two pilot areas: the natural river Túr and the artificial and less important Kállay Channel. Both areas can be found in the north-east of the country. Household willingness to pay for an improvement in the state of the water bodies is similar for both; most are ready to dedicate only a small proportion of their monthly income, equivalent to 0.5%. The relatively high proportion of zero offers can be mainly explained by the low level of income characteristic of the surveyed areas. The results of the survey can be used in a cost-benefit analysis to provide a basis for future programmes as well as coordinating international efforts for improving the water quality of catchment areas. In addition, companies also can make use of those results for their environmental performance evaluation processes.

Keywords Water Framework Directive • Contingent valuation • Hungary • Water • Cost-benefit analysis

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1 Introduction

The main issue arising from the project *Promoting Implementation of Water Framework Directive Phase II*[1] was how to select the necessary measures to improve water bodies, taking into account the alternatives in the light of the need for cost efficiency, to fulfil the requirements of the *Water Framework Directive* in Hungary. Because of this requirement for cost efficiency, further criteria are required to assist in decision-making and benefits stemming from the indirect impacts of measures taken can be considered. It is reasonable to evaluate part of the indirect impact in monetary terms, but there are several elements among these impacts which are very hard to monetise: beauty of the landscape, positive changes in the state of water quality, habitat, or changes in flora and fauna. To calculate these impacts, stated preference procedures such as contingent valuation, choice experiment and contingent ranking are considered to be the most appropriate (Boxall et al. 1996).

Within the framework of the project, nine diverse pilot areas are selected and a model for cost efficiency analysis is tested. In relation to potential intervention, it is important to discover which benefits are linked with high-cost solutions and whether such costs are disproportionately high. Analysing the consequences of indirect impacts using an economic method is also necessary. Primary research was carried out in two case study areas: the catchment basin of the Túr and the Kállay-channel, both located in north-eastern Hungary. The Túr is a natural river with significant value for recreational use, while the Kállay Channel is an artificial river used less for recreational purposes and is of lower importance. Recreational use is considered liable to influence willingness to pay.

The main objectives of the research are:

1. To explore whether there is willingness to pay (WTP) by local inhabitants for development of the sample catchment areas and how they evaluate any management measures stemming from attempts to meet the requirements of the *Water Framework Directive* such as improving the state of flora and fauna and the beauty of landscape through WTP;
2. Based on these results, to formulate recommendations which can help estimate the magnitude of benefits regarding development measures in practice; and
3. To discuss the relevance of these findings to business.

Data were collected through a face-to-face contingent valuation survey carried out in April 2007.

[1]The research was carried out in the frame of the project titled 'Promoting Implementation of Water Framework Directive Phase II. (2006–2007)'. The principal was Ministry of Environment and Water Affairs, the implementer was the consortium lead by ÖKO Zrt. (members: Budapest University of Technology and Economics, Department of Water Utility and Environmental Engineering; VTK Innosystem Water, Nature and Environment Protection Ltd.; ARCADIS Euroconsult BV).

2 Method: Contingent Valuation

Contingent valuation is an economic assessment method which explores personal preferences in a direct way primarily in connection with determining the economic value of non-market goods (Garrod and Willis 1999, Hoevenagel 1994, Mitchell and Carson 1989). Through a questionnaire, a hypothetical market was created where some change in the state of the goods under consideration occurs and the willingness to pay/accept a change in the state of those goods is explored. The procedure assumes that amounts of payment/acceptance are appropriate for revealing the preferences of participants.

In relation to benefits stemming from the implementation of *Water Framework Directive* obligations, several surveys have recently been carried out in Europe most frequently employing contingent valuation and choice experiment evaluation methods.

Bateman et al. (2006) undertake research using contingent valuation and contingent ranking related to the water quality improvement of the River Tame in Great Britain. Three improvement packages are compared – small, medium and large improvements – firstly through contingent valuation methods then, using the same sample and within the same questionnaire, through contingent ranking. Areas for improvement are classified as being fish population and fishing opportunities, presence of other creatures, and opportunity for boating and swimming. In the case of contingent valuation, every alternative is initially introduced to participants and an open-ended question formulated to elicit willingness to pay for a small improvement for one half of the sample and a large improvement for the other half of the sample.

Atkins and Burdon (2006) carry out research in Denmark regarding the implementation of the *Water Framework Directive*. They examine societal preferences towards water quality improvements in connection with reducing eutrophication levels of the Danish Randers Fjord through analysing WTP.

Other surveys relating to the *Water Framework Directive* include a choice experiment survey conducted by Hanley et al. (2006a) for the rivers Wear in England and Clyde in Scotland. Hanley et al. (2006b) also carry out a choice experiment survey in Great Britain wherein a water quality improvement WTP relating to the catchment basins of two rivers, the Motray and Brothrock is estimated. In addition, Alvarez-Farizo et al. (2007) conduct research in connection with the Spanish River Cidacos using the choice experiment method.

This literature suggests that the most recent evaluation surveys tend towards the application of choice experiment methodology. However, the authors of this paper decided to use contingent valuation in Hungary for five reasons: (1) difficulties in quantification of choices, (2) appropriateness of method for an estimate of total economic value, (3) previous use of method within the Hungarian context, (4) time and budget constraints, and (5) reliability of the method for small samples. In the case of changes which are difficult to quantify, contingent valuation is one of the most frequently used methods – being methodologically well-founded among stated preference procedures and with well-known advantages and disadvantages. As indirect impacts of developing catchment areas primarily improve natural states which are one of those goods most difficult to quantify, the use of this procedural method is justified. Contingent valuation is appropriate for the estimation of total economic value and so a wide-scale exploration of value change becomes possible. In Hungary, only contingent valuation (from the set of revealed preference methods) has thus far been used. In relation to water, two surveys have been carried out: one regarding the value of a water quality improvement in Hungary's biggest lake, the Balaton (Mourato et al. 1997), the other connected to evaluating the impact on nature of the Slovak-initiated diversion of the Danube on Hungary's northern border (Fucskó et al. 2001). Hungary has no previous experience of choice experiment application (until 2007).

3 Characteristics of the Samples

The study was carried out through surveying households living in the two pilot areas, the catchment basin of the River Túr and that of Kállay Channel. Two criteria – distance from the water body and size of the settlements – were used for selecting the settlements for the sample. It was assumed that settlement size would influence community values and also values assigned to the River Túr and the Kállay Channel. Settlements were divided into three size categories: small (at Túr under 1000, at Kállay under 1,500 inhabitants), medium (between 1,001–3,000 inhabitants at Túr and between 1,501–5,000 inhabitants at Kállay) and large (at Túr over 3,001, at Kállay over 5,001 inhabitants). Distance of resident's homes from the water body in question is an important variable.

Households in the settlements were randomly selected and the survey was conducted on weekends in order to ensure inclusion of employed people in the sample. The response rate was high (93.5%), because of the method of inquiry – personal interview and attitude of respondents who were relatively time-rich and willing to help.

In the case of the Túr sample, the proportion of men is somewhat smaller than the average for the county; in the case of the Kállay Channel, men are overrepresented in the sample. In relation to age, respondents between 50–62 years old are overrepresented in both samples. Average family size corresponds well to average national data. On average, respondents have been living in the areas for more than 35 years; the majority were born in the area being examined. The unemployment rate is higher in the Túr sample compared with Kállay. The proportion of pensioners is bigger in the Túr sample than the average for the county; in the Kállay sample, it is lower. In both samples, there was over-representation of people with higher education qualifications, while under-representation of less well-educated people is characteristic. Net monthly household income stated by the respondents was on an average HUF125,000 (€500) at the Túr, but remarkably higher – HUF156,000 (€624) at the Kállay-channel. Comparing the socio-economic data of the two areas, there are several similarities in their characteristics but the income of people living near the Túr is significantly lower than that of inhabitants of the Kállay area. This can be partly explained by proportionately fewer elderly and unemployed respondents in the Kállay sample. With these features in mind, the questionnaire is next addressed.

4 The Questionnaire

For the two sample areas, the same basic questionnaires were used although they differed in relation to a few local special considerations. Questions covered four areas:

- Survey circumstances (administrative questions);
- Attitudes to the water body;
- Economic valuation (WTP); and
- Socio-economic characteristics of the sample.

In relation to attitudes to the water body, emphasis was given to the following: activities are pursued by respondents at Túr/Kállay, frequency of activity, and do respondents also visit other surface water areas. In addition, a question on perceived water quality was included.

Valuation questions were introduced by providing information about the present situation followed by information about a programme that would result in a better ecological state/potential (based on Progress Report No. 3, Annex 21 2006). In the questionnaire, the estimated outcome of the hypothetical measure was based on real data and realistic plans regarding the areas striving to weaken the hypothetical character of the scenario and maintain credibility. In relation to willingness to pay, an open-ended question was included, followed by questions designed to discover reasons behind willingness or refusal to pay. In order to eliminate the amenity misspecification problem (see Magnussen 1992, Mitchell and Carson 1989), a follow-up question was included on whether the amount offered related exclusively to the Túr/Kállay Channel or generally to environmental problem solving. The analysis then focused on how use and non-use elements of total economic value are reflected in these hypothetical payments. Finally, respondents were asked whether they would use the surface water in question more often after implementation of the proposed measures.

At the end of the questionnaire, socio-economic details of respondents (age, sex, qualification, family size, number employed in the family, profession, income) were gathered along with aspects which were presumed to have an impact on WTP, such as, how long respondents had been living in the area or whether they pursued agricultural activities. In this article, only the results of WTP are introduced.

5 Results

5.1 Results of WTP Analysis

The most important part of the survey is the valuation question section. The valuation question was phrased in an open-ended format:

> Let us assume that a separate fund will be set for managing inhabitants' contributions which only could be used for the implementation of the above program. If you support the program, what is the regular monthly maximum contribution of your family/household which you would be willing to pay for ten years for program implementation? Please indicate an amount which you really would be able to sacrifice for this purpose! When answering, please consider the actual income situation of your family/household.

As is evident from the question, monthly household-level willingness to pay was examined. Two aspects were considered when selecting the payment vehicle: frequency and personal or household level of payment. The monthly frequency fits better to the respondents' habits to pay the water bill and receive their income. The household-level of payment also seemed more appropriate as family features, such as number of children, can be better considered, when offering a payment. Furthermore, because of adverse attitudes to the tax system in Hungary, voluntary payment into a dedicated fund was regarded as the most appropriate form of payment.

A first step in WTP analysis is screening out invalid answers from respondents. According to the literature, some part of all zero offers and high-end WTPs should be treated outliers. In the case of zero bids, two categories can be identified: valid and invalid. A zero offer can be regarded as valid if there is an economic rationale behind it – such as a low income level which prevents respondents making sacrifices for this purpose or if the area examined genuinely does not have any positive value for respondents (Freeman 1994). To separate valid from invalid answers, a follow-up question was used in the questionnaire which asked participants to formulate the main reason behind their zero offers.

In the case of the Túr, 31% of the respondents offered to pay zero amounts. The overwhelming majority of zero offer answers were regarded as valid; they were most frequently explained by low family income levels (59%). A significantly lower number mentioned that they do not use the water body (14.1%). At the Kállay Channel, 39% offered zero amounts, also mainly referring to their low income (66%) and lack of use (8.5%). In both samples, the main reasons for the high rate of zero offers include the poor economic situation of the area, the relative poverty of inhabitants compared with the country average as well as a high unemployment rate. Unrealistically high amounts were offered by an insignificant number of respondents. To avoid distortion, these were excluded from the sample as invalid answers.

Based on valid answers, the monthly average offered was HUF931 (€3.7)/month for the Túr and HUF1010 (€4) for the Kállay Channel. The majority of people would give HUF1000 (€4) for programme implementation in both pilot areas. Results of the WTP-analysis are summarised in Table 13.1.

Table 13.1 WTP in the two pilot areas

Results of maximum willingness to pay of individuals	Frequency	
	Túr	Kállay channel
WTP = 0	73	87
Valid WTP = 0	68	84
WTP > 0	160	138
Valid positive WTP	157	138
Missing	–	–
Average WTP	HUF931 (€3.7)	HUF1,010 (€4.0)
Variance	HUF1,527	HUF2,358
Median	HUF500 (€2.0)	HUF500 (€2.0)
Minimum (for positive WTP)	HUF8	HUF42
Maximum	HUF10,000	HUF30,000
Valid *N*	225	222

€1 = HUF250

Amenity misspecification is a frequent phenomenon during contingent valuation. In order to eliminate and analyse it, the following question was added to the valuation section:

> You said you are willing to sacrifice a certain amount of money for improving the state of Túr/Kállay-channel. However, people often have a problem when separating the amount specified for one single program in contrast to that offered for a whole environment protection programme. Would you say whether you offered the specified amount for improving the state of Túr/Kállay-channel only or for other environmental purposes as well?

In the case that respondents offered the amount for other objectives as well, they had a chance to modify the amount in the frame of an open-ended question. Results are very similar in both pilot areas. Slightly more than half of the people who offered positive amounts did not modify their original offers; the other (nearly) half reduced them. The majority of the latter group reduced their original offers by almost half. The average degree of amenity misspecification is 75.5% at Túr and 77.1% at the Kállay Channel. On this basis, the average maximum willingness to pay calculated decreased to HUF649 (€2.6) for the Túr exclusively and to HUF819 (€3.3) in the case of the Kállay.

Beyond WTP, it is interesting how objectives related to use and non-use values were weighted. Hence, respondents with positive WTP were asked to divide the amount they offered between these two categories. Importance of the use-related objectives was characterised in improvement of holiday and recreation opportunities as well as by solving flood problems, while objectives independent from use which were considered important included increasing number of fish species, improvement in the state of backwaters and by increase in proportion of water-based habitat. A use/non-use value division of 50–50% was chosen by the majority of respondents in both samples. However, in the case of the Túr, the proportion of respondents preferring use-related objectives was significantly higher. The ratio of participants devoting the amount exclusively to non-use purposes is practically the same (5.2% for Túr; 6.5% for Kállay). The importance of non-use value is highlighted in Fig. 13.1.

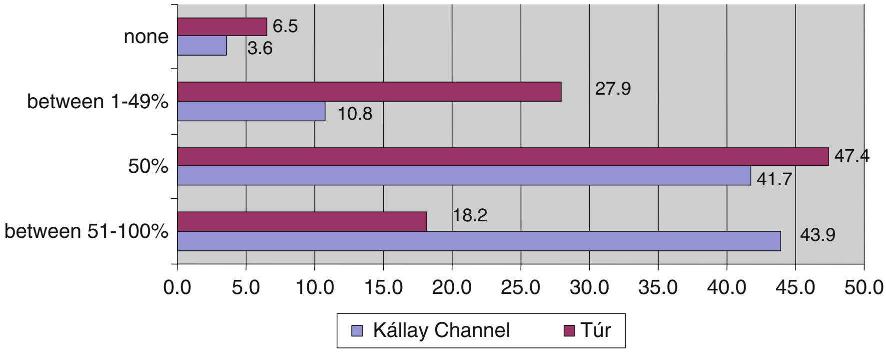

Fig. 13.1 Ratio of the amount offered for non-use value (% of answers)

5.2 Regression Analysis

An important step of contingent valuation is the estimation of the bid curve which was undertaken through a multivariate regression analysis. During this process, the factors affecting willingness to pay, their direction and size are estimated in a model.

In contingent valuation literature, the explanation of open-ended WTP estimates is generally provided through a model called the valuation curve or bid curve; however, WTP is estimated as a function of possible explanatory variables (see equation 13.1)

$$\mathrm{WTP}_i = f(X_i), \tag{13.1}$$

where WTP_i represents the maximum willingness to pay of the *i*-th individual and X_i is a vector composed of independent variables affecting the individual values.

The most general specification of the bid curve assumes a linear relationship between the variables (see equation 13.2)

$$\mathrm{WTP}_i = \beta * X_i + \varepsilon_i, \tag{13.2}$$

where β is a vector composed of parameters describing how a change occurring in a given independent variable affects the WTP and ε_i is the random error component comprising the effects of factors unobservable by the researchers, distributed normally with an average of zero and constant variance (see, e.g. Mourato et al. 1997). In contingent valuation, the criteria for the variance explained by the model are much less stringent; according to Mitchell and Carson (1989), an adjusted R^2 value of 15% is acceptable.

As a dependent variable, both the maximum willingness to pay (mentioned first) and WTP corrected for amenity misspecification were used. During the first estimates, several characteristics were included in the model and those which provided the best fit were kept – and are presented in the following explanation. Models were only able to explain a small proportion of the variance in WTP, just less than the 15%

Table 13.2 Descriptive statistics of the variables influencing the WTP included in the model

Explanation of the variable	Túr	Kállay-channel
	Average and proportions	
WTP offered only for the Túrra/Kállayra (Ft)	617	847
Net monthly income of the family taken as the central value of the category (Ft)	125,120	149,754
Frequent walks by the Túr (1 - yes, 0 - no)	0.28	
Indicated more frequent use if the condition of the Túr/Kállay-channel were to improve (1 - yes, 0 - no)	0.70	0.74
Pursues agricultural activity (1 - yes, 0 - no)	0.42	
Distance of the locality from the Túr (1: up to 8 km; and 2: over 8 km)	1.64	
Uses the Túr as well as other substitutes (1: yes, 0: no)	0.5	
Frequently uses the Kállay for any activity (1: yes, 0: no)		0.12
Age of the respondent by age group (1: 18–29 years, 2: 30–39 years, 3: 40–49 years, 4: 50–62 years, 5: over 62 years)		2.86
Place for pursuing water related activities (1: only at Kállay, 0: nowhere, only other places, at both)		0.12
	N = 208	*N* = 203

considered the acceptable minimum by Mitchell and Carson (1989). This result could be explained by the fact that only a very small proportion of income – 0.5% on average – was offered for an improvement of the goods evaluated. Table 13.2 provides an overview of the variables included in the model.

Table 13.3 summarises the main parameters of the estimated models. The direction of the effect of individual variables generally corresponds with expectations. Only a part of the results are significant.

Because of missing values in both cases, the multivariate regression included data from fewer respondents than the original sample size. In both sample areas, two variables were found to affect the WTP in a positive way:

- Income: respondents with higher incomes are willing to pay significantly more than families with lower incomes and
- Intention to increase frequency of use where the condition is improved; people who feel motivated to use the water body more frequently as a result of improved conditions are not willing to pay more, but not significantly more in either sample area.

In case of the Túr, four additional variables are included in the model frequent walks, agricultural activity, distance from water body, and use of other water bodies. Frequent walks have the highest positive impact. Respondents walking at least once a month along the Túr would pay 322 Ft (€1.3) more for improvement of the river condition. Agricultural activity has the second strongest influence; people involved in agriculture are willing to pay 288 Ft (€1.15) more on average, per month. This effect is contrary to the expectations, since the proposed measures

Table 13.3 Multivariate models estimated by linear regression (*t*-values are in parentheses)

Variable	Túr	Kállay-channel
	Parameter estimate	
Net monthly income of the family taken as the central value of the category (Ft)	0.002** (2.143)	0.005** (2.510)
Frequent walks by the Túr (1: yes, 0: no)	322.299** (2.122)	
Indicated more frequent use if the condition of the Túr/Kállay-channel was to improve (1: yes, 0: no)	133.235 (0.984)	499.293 (–1.374)
Pursues agricultural activity (1: yes, 0: no)	288.291** (2.349)	
Distance of the locality from the Túr (1: up to 8 km; 2: over 8 km)	–289.528** (–2.152)	
Uses the Túr as well as substitutes (1: yes, 0: no)	250.872* (1.814)	
Frequently uses the Kállay for any activity (1: yes, 0: no)		1,248.977** (2.590)
Age of the respondent by age group (1: 18–29 years, 2: 30–39 years, 3: 40–49 years, 4: 50–62 years, 5: above 62 years)		–138.073 (–1.104)
Place for pursuing water related activities (1: only at Kállay, 0: nowhere, only elsewhere, at both)		1,188.996** (2.534)
Constant	415.46 (1.814)	–166.115 (–0.255)
R^2	17.2	16.0
Adjusted R^2	14.8	13.8
F-test	6.980	7.486
Sign. F	0.000	0.000
	$N = 208$	$N = 203$

$^{**}P < 0.05$; $^{*}P < 0.1$

Dependent variable: maximum willingness to pay corrected for amenity misspecification

could be assumed to restrict agricultural activity, resulting in a possible loss of income. Distance has a negative impact meaning that those living further away from the Túr are willing to offer less for its improvement. In this sample, respondents who prefer to visit and use other rivers have considerably higher willingness to pay – 251 Ft (€1.0) – than those who prefer only to visit and use the Túr, only other rivers, or none at all (significant at a 10% level).

In the case of the Kállay Channel, three additional variables seem to have relevant impact on WTP. Current use has the greatest influence on the WTP; frequent users of the channel (at least once a month) would be willing to pay 1,249 Ft (€5.0) more for the programme (monthly, on average) than rare-users or non-users. This is a very large additional amount and clearly indicates the importance of sensitivity analysis. Respondents using only the Kállay Channel for water-related activities offered 1,189 Ft (€4.8) more than those additionally or exclusively frequenting other waters or none at all. Those who would use the channel more if the programme was implemented (potential users) would pay 499 Ft (€2.0) more than those who would not visit it more often than before. The age of the respondents is inversely related to willingness to pay. A 10-year increase in age results in a 138 Ft (€0.55) lower amount in WTP.

Overall, it can be stated that in general both samples provide results in line with economic expectations but the explanatory strength of the models is not evident (14.8% and 13.8%). This means that several factors that can influence willingness to pay were not included in the survey or cannot be discerned.

5.3 Aggregation

In contingent valuation, determination of the average willingness to pay of individuals or households is followed by aggregation of the data during which the results for the entire population involved are calculated. The data need to be aggregated for the group of people whose welfare is affected by the programme to improve the condition of the Túr/Kállay. According to Santos (1998), the size of the population used in the aggregation process is the most important and most influential factor next to the WTP in the estimation of benefits. This problem exists in the present study especially in relation to the Túr. The units of observation in the research were households, so the amount of annual benefit is estimated based on the number of households affected. The simplest method of aggregation is to multiply average willingness to pay by the number of affected households. Results are summarised in Table 13.4.

As seen in Table 13.4, the aggregate (monthly and annual) WTP for the improvement programmes is very high in both areas. However, the aggregation is distorted by the fact that only households living on the designated sample areas were included in the calculation. Two opposite impacts should be taken into account. The dense network of surface waterways in the observed areas means that the population can relate to and attach value to several of the waterways. In the survey, only the use of other waterways was captured not the actual value attached to them. This could result in an overestimation of household WTP. The other distorting

Table 13.4 Results of aggregation

	Túr	Kállay-channel
Number of households in the area	12,127	16,916
Average monthly WTP in the sample	649 Ft (€2.6)	819 Ft (€3.3)
Monthly WTP calculated for the whole area, for the improvement of water quality	7.9 M HUF (€31,600)	13.9 M HUF (€55,600)
Annual WTP calculated for the whole area, for the improvement of water quality	94.5 M HUF (€378,000)	166 M HUF (€664,000)

effect lies in determining the area where households are actually involved in the issue. The Kállay Channel is only of local importance; those living nearby are fond of it and use it, but people do not come into the area from a greater distance to visit the channel although the increase of wetland territory also might have value for those outside the area. The Túr, however, can be regarded as of national importance and therefore, the entire population of the county or even the country should be considered; their WTP, however, was not part of the research.

Because of critical points of the research, our estimates suggest WTP, the annual amount in the case of an artificial waterway of local significance, is almost double than that for a nationally important river in natural condition with substantial recreational potential. The result was caused by two factors: differences in income, and in the number of households. When using the results for environmental policy purposes, it is important to consider these factors.

6 Evaluation of the Results

While comparing the data from the two sample sites, it was discovered that the proportion of respondents that expressed zero willingness to pay was slightly lower in case of the Túr (31%) than the Kállay (40%), despite average income is significantly higher at the latter. The explanation for the zero offers however was similar for both bodies with the majority not willing to pay because of their low income (60% in the Túr sample and 66% in the Kállay sample) and not because the waterway is of no importance to them. As expected, based on the statistical data and the nature of the waterways, use of the waterway is significantly lower in the case of the Kállay.

Comparing the WTP value of the two samples, the average amount first offered was HUF931 (€3.7) for the Túr and HUF1,010 (€4.0) for the Kállay channel – this difference is not statistically significant. There is also no significant difference in the WTP amounts destined solely for the river in question – HUF647 (€2.6)/month/household for the Túr and HUF819 (€3.3) for the Kállay (annually HUF7,800 and HUF9,800 (€31 and €39) respectively) were estimated. The results also reveal that a misunderstanding of the scenario was also similar in the two sample areas – around 75%.

As expected, an increase in distance results in a decrease in willingness to pay in both cases, although only in one case was it significant. Respondents living at a greater distance stated a willingness to pay of 52% in case of the Túr and 55% in case of the Kállay of the sum offered by those living nearby. In the two sample areas, both overlapping and conflicting factors significantly affect the WTP. Income, frequent use, and indication of more frequent use after implementation of the programme, point in the same direction. In the case of the Túr, agricultural activity, and in case of the Kállay, visiting the channel, were additional factors which considerably affected WTPs.

The average WTP amounts offered represent practically the same proportion of incomes in both areas. The sum dedicated to the specific river in question was 0.5% for the Túr and 0.56% for the Kállay. This result does not correspond to the expectations that willingness to pay in the case of the Túr would be significantly higher, it being a natural river with considerable tourist value while the Kállay channel is artificial, although providing a natural effect, and is much less attractive from the perspective of tourists. However, one constraint when interpreting the results is that only locals and no tourists were interviewed. It should be noted that offering a similar amount from a lower income is of higher significance, as one HUF (€) WTP is a larger fraction of income for someone with a lower income.

Transferability of the findings is limited by a number of factors: first, only residents of the sampling areas were surveyed and other groups who live outside but may also be affected were excluded. The effect is more important in case of the Túr which should have higher value as a cultural resource, as it appears in one of Hungary's most famous poet's (Petőfi Sándor) poems, whereas the Kállay Channel is only of local significance. Second, the survey showed that willingness to pay decreases with distance from the waterway, but as the sample areas were relatively small this effect cannot be estimated over larger distances. Third, the high proportion of zero bids in both samples raises an important issue as a follow-up question showed that approximately two-thirds of the respondents making zero offers had low income.

7 Conclusions

The results of the survey can be used cautiously primarily in cost-benefit analyses to provide a basis for developing future programmes relating to charges for visitors to river areas. Based on cost-benefit analysis, it is possible to evaluate and decide whether plans are beneficial for society or too costly and which of the management options is more favourable, taking into account the main direct and indirect effects of engineering solutions aiming to achieve water quality standards set in the *Water Framework Directive*.

The text of the *Water Framework Directive* does not mention cost-benefit analysis, as one interpretation of disproportionate costs is that costs exceed benefits. Costs are considered disproportionate if the net present value of the amount necessary to implement the measures is higher than their direct and indirect socioeconomic benefits, including environmental benefits. Through using the results of the two case studies, a methodological guide has been prepared on cost-benefit analysis.

The survey resulted in an average household willingness to pay for 600–800 Ft per month.

To estimate the benefits attached to a given catchment area, consideration of two possible modifications is suggested. One is the significance of the waterway, which is determined in part by its character and by the importance of its uses. When determining the significance, local characteristics are decisive. Public participation can be a helpful tool in assessing significance by providing information on the use of the water body by the stakeholders. This can be done by using a list of typical activities connected with the river. The results would show how widely the possible uses are being exploited thus allowing judgement about the importance of the waterway to the population. The other modifying factor is the inhabitants' income. An average income needs to be calculated for each catchment area to be examined. When performing benefit transfer analysis, income is compared to the average net income of the catchment area, from where the WTP values are derived and individual WTP value is further adjusted using the resulting ratio.

According to the survey, people attach a slightly higher value to features associated with use, but would spend on average 45% of the amount offered on non-use characteristics. Therefore it is suggested that 55% of the WTP only is multiplied by the number of people directly affected – those living in settlements close to the waterway – and 45% by the population of the entire catchment area. In addition, in the case of a waterway or section of regional or national significance, the WTP, or part of it, can also be calculated for the region or the entire country.

The area-level cost-benefit analyses based on the guide are suitable for preparing ministry decisions about derogations to be requested from the European Union. They serve the goal of increased public participation, which is required during the planning stage. The results of cost-benefit analyses can also be used in coordinating international efforts for improving the water quality of catchment areas. The analyses should be prepared as part of the catchment area management plans, but should be separately documented. It is instructive to present the results of the WTP-survey and the cost-benefit analysis during public discussions organised in the given areas.

It should be emphasised that the cost-benefit analysis used for determining the socio-economic benefits and costs of proposed measures is an important tool for preparing programmes supporting decisions and economic analysis. The analysis also plays a vital role in assessing the cost-efficiency of various measures and affordability studies. Further analysis of the environmental effects is necessary using natural indicators and/or qualitative techniques.

The results of contingent valuation can also be utilised by companies when assessing their environmental or sustainability performance. The indicator system of the ISO 14031 standard for corporate environmental performance evaluation includes a category called *environmental condition indicators* which are designed to reflect the environmental impact or load of the company on the quality of air, water, land, flora, fauna, etc. The result of a WTP analysis provides information for analysis of those environmental condition indicators. There are already examples from company practice where these methods have been used to estimate the effect of the company strategy on sustainability and to determine stakeholder reactions: a large oil and gas producer carried out such WTP analysis in the affected community in order to improve decisions about offshore oil exploration (see Epstein 2008:143–144). The same is true for some energy companies, as a consequence of residents' concerns about natural gas drilling in their area (Epstein 2008:156).

Companies with high environmental risks arising from their activities are increasingly made responsible for their negative environmental impacts by stakeholders who create the necessity for those companies to use methods capable of assessing the environmental effects of their operations and the priorities of their stakeholders with the overall objective of maintaining their reputations and licences to operate.

References

Alvarez-Farizo B, Hanley NR and Barberán AL (2007) Choice modelling at the "market stall": individual versus collective interest in environmental valuation *Ecological Economics* 60.4 743–751

Atkins JP and Burdon D (2006) An initial economic evaluation of water quality improvements in the Randers Fjord, Denmark *Marine Pollution Bulletin* 53.1-4 195–204

Bateman IJ, Cole MA, Georgiu S and Hadley DJ (2006) Comparing contingent valuation and contingent ranking: a case study considering the benefits of urban river quality improvements *Journal of Environmental Management* 79.3 221–231

Boxall PC, Adamowitz WL, Swait J, Williams M and Louviere J (1996) A comparison of stated preference methods for environmental valuation *Ecological Economics* 18.3 243–253

Epstein MJ (2008) *Making Sustainability Work, Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts* UK, Greenleaf Publishing

Freeman III AM (1994) *The Measurement of Environmental and Resource Values: Theory and Methods* Washington DC, Resources for the Future

Fucskó J, Garrod G, Powell J and Valené Kelemen Á (2001) *A Szigetköz és a Dunakanyar Természeti Tőkéjének Értékelése (The Economic Valuation of Natural Resources in Szigetköz and Dunakanyar)* Budapest, MAKK

Garrod G and Willis KG (1999) *Economic Valuation of the Environment. Methods and Case Studies* Cheltenham, Edward Elgar Publishing Ltd.

Hanley N, Wright RE and Alvarez-Farizo B (2006a) Estimating the economic value of improvements in river ecology using choice experiments: an application to the water framework directive *Journal of Environmental Management* 78.2 183–193

Hanley N, Colombo S, Tinch D, Black A and Aftab A (2006b) Estimating the benefits of water quality improvements under the Water Framework Directive: are benefits transferable? *European Review of Agricultural Economics* 33.3 391–413

Hoevenagel R (1994) *The Contingent Valuation Method: Scope and Validity*, Ph.D. ThesisAmsterdam Free University

Magnussen K (1992) Valuation of reduced water pollution using the contingent valuation method – testing for mental accounts and amenity misspecification in Navrud S *Pricing the European Environment* Oslo, Scandinavian University Press 195–230

Mitchell RC and Carson RT (1989) *Using Surveys to Value Public Goods: The Contingent Valuation Method* Washington DC, Resources for the Future

Mourato S, Csutora M, Marjainé Szerényi Zs, Pearce D, Kerekes S and Kovács E (1997) The value of water quality improvement at Lake Balaton: a contingent valuation study (ch. 6) *in Measurement and Achievement of Sustainable Development in Eastern Europe* Report to DGXII Budapest, Budapest Academy of Economic Sciences, Bulgarian Academy of Sciences and Cracow Academy of Economics

Progress Report No. 3, Annex 21 (2006) Promoting Implementation of Water Framework Directive Phase II: Description of the case study areas, results of the ecological survey and proposals to take measures (available only in Hungarian)

Santos JML (1998) *The Economic Valuation of Landscape Change. Theory and Policies for Land Use and Conservation* Cheltenham, Edward Elgar Publishing Ltd.

Chapter 14
Health, Safety and Environmental Costs and Chemical Selection in the Oilfield Industry: A Method for Informed Decisions During Project Planning

Ylva Gilbert and Anna Kumpulainen

Abstract The oilfield industry uses vast amounts of chemicals to find and produce hydrocarbons. Chemical choices can significantly influence the health, safety and environmental consequences and risks of an oil well construction project. Each consequence and risk comes with a price tag. To select the most cost-effective chemical, the effect of chemical hazard on overall project economics must be included in assessments. Available methods can be laborious and seldom cover all health, safety and environmental consequences. Overall health, safety and environmental cost effects of chemical choice have not been translated into practical tools and thus the health, safety and environmental costs have rarely been calculated for oil well construction.

This chapter describes a new method and accompanying tool for assessing overall costs of chemical use. It combines predicted health, safety and environmental cost at risk with direct operational cost consequences of chemical hazard profiles. The method allows easy comparison of overall cost attributable to chemical choice. Comparing two high-density completion brines, a key consideration was to create a practical tool that allows environmental management accounting principles to be used as inputs into the project planning and purchasing stage. The approach developed represents a significant advance in making environmental management accounting principles easily accessible for everyday decision-making in the oilfield industry.

Keywords Oilfield industry • Oil well construction fluid • Health, safety and environmental risk • Health, safety and environmental cost

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1 Introduction

Oil and gas are produced through wells drilled into hydrocarbon-bearing rock formations, often deep underground and sometimes in challenging offshore environments. Construction operations cover three main stages: drilling the well, providing structural support and zonal isolation for the hole created, through cementing, and completing the oil well in readiness for bringing it into production. All stages of production use large amounts of specialist chemicals. The world market for all oil field chemicals reached almost US$8 billion in 2004 and was expected to total over US$9 billion in 2009 (Modler and Inoguchi 2005). Chemicals, or so-called well construction fluids and fluid additives used to drill and complete wells, form a significant part of this total. The project management of oil well construction is generally undertaken by a team of engineers and inevitably engineering considerations are of prime importance to ensure technical success. The overall project is managed through teams concentrated on specific technical disciplines (e.g. drilling, cementing and completion) with considerable independence from each other. Whilst the overall project is centrally coordinated and supply chain management is of prime importance, the individual teams mostly have separate and sometimes uncoordinated budgets. Crosscutting issues, such as overall health, safety and environmental (HSE)-related costs, may therefore never be estimated during the planning stage or considered as a whole during analysis of overall post-operational costs.

In offshore deep-water sites the construction phase cost can reach up to US$100 million per oil well and the cost of chemicals may account for 10% of this bill. Often the chemical budget will only be based on immediate tangible costs, i.e. the price of chemicals. However, inherent hazardous chemical properties can also significantly influence direct operational costs and diminish returns on investment. Chemical choice can have a profound impact on both direct operational and HSE-related costs and returns on investments by influencing the:

- Overall cost of construction process through specific chemical technical properties
- Cost of time to bring the oil well to full production
- Overall waste management bill
- HSE compliance and risk management costs during operations
- Overall productivity and long-term integrity of the well
- Future liabilities (environmental or health exposure–related) (Gilbert et al. 2008b, 2009)

As the overall operational consequences impact on several budgets it may considerably influence overall project economics and be of interest to the financial management of the oilfield operator. For example, fluid-related delays can add to the operational time of drilling rigs which in offshore deep-water sites can add to the cost with up to US$1 million a day. Limiting the financial impact of chemical choice to direct chemical costs is clearly not optimal (Gilbert et al. 2009).

To include environmental- and health-related accounting principles in planning work is in theory a simple matter. Extension of the concept to eco-efficiency analysis, i.e. consideration of overall life cycle impact (ecological, toxicological and societal) and overall operational cost of a chemical in relation to the overall technical benefits, is also a relatively simple yet data-intensive exercise (for example, see Olsthoorn et al. 2001, Verfaillie and Bidwell 2000). In practice, the inclusion of comprehensive eco-efficiency analysis or even chemical-related HSE cost considerations in the decisions on which chemicals to use in an oil well construction operation has rarely been done. In this chapter, the eco-toxicological consequences of planned and unplanned discharges as well as the medical consequences of human exposure to the chemical are used as a basis for the estimation of the related costs of restoration, remediation and health care. By including the direct costs of HSE risks, a useful overall HSE cost prediction of chemical choice is obtainable. The benefit to the customer is completion of the overall process. Combining the HSE costs with the calculation of operational costs related to the chemical choice produces results indicating the overall chemical HSE efficiency of the process, i.e. produces a partial eco-efficiency indicator for the chemicals used within that particular process.

However, there are issues to overcome before even a limited eco-efficiency consideration can be successfully included in the project planning process. An immediate practical problem faced by the operational management team is the question of how to gather and analyse all the pertinent input data needed. In fact, this issue represents quite a high threshold for carrying out such evaluations, as it would appear that the basis for pure cost comparisons, i.e. overall operational costs related to chemical use, is not routinely analysed. As this type of data is directly related to operational performance but also requires costing of HSE consequences, the calculations require cross-disciplinary cooperation between HSE and technical experts. The theoretical challenges of HSE risk costing are mainly associated with ethical dilemmas relating to the costing of HSE risk – a topic amply reviewed in the literature (e.g. Bennett et al. 2003, Dixon 1998, IFAC 2005, Rikhardsson et al. 2005, UNDSD 2001, US EPA 1996) and discussed in detail in relation to oil well construction fluid costs in previous papers (Gilbert and Kumpulainen 2008, Gilbert et al. 2008b). There are two practical challenges: data availability and collation and data comparability.

1. Data availability and collation: The data, including costs, have to be gathered from a number of different functional groups within the asset team, e.g. oil well engineering, sub-surface operations, logistics, HSE, production. These may not be readily available, because certain variables are not routinely tracked.
2. Data comparability: Some of the data may not be easily comparable or quantifiable, because not all consequences of using a particular chemical are easy to convert into costs.

To include chemical HSE influences in the overall budget planning exercise the relevant data must be identified, collated, converted to common units and total costs calculated. To be of real value to the management team, it is of considerable importance that such a process is easy to carry out, does not require specific expertise to use and the results are presented in a succinct and easy-to-understand format.

This chapter presents a practical method and accompanying tool that allows collation of data and assessment of the overall operational and HSE-related costs, HSE consequences and risks associated with oil well construction fluids. The tool supports informed decision-making in line with environmental management accounting (EMA) principles. The aim is to create a framework for data input by identifying all relevant end costs and their methods of calculation and using these to identify the variables that can be used as inputs in the tool. By incorporating fixed calculations, conversions and estimations in an Excel-based tool, the overall result is a practical and rapid approach for comparing and analysing chemical choice.

The structure proceeds, in Sect. 2, with the introduction to the aim, objectives and method of the research. The section includes an overview of the oil well construction process in relation to overall cost assessment. Section 3 details the choice and construction of a framework that supports overall cost identification and is in line with EMA principles. Chemicals and chemical risk management requirements are detailed in Sect. 4. Section 5 presents a model for converting HSE risks into costs, and details the supporting tool created for undertaking the assessment. The findings are discussed in Sect. 6, followed by conclusions put forward in the final section.

2 Aim, Objective and Method

Oilfield chemicals are required to meet strict technical and HSE criteria. A chemical has the potential for creating HSE impacts during its entire life cycle. One of the life cycle stages, the manufacturing of the chemical, is outside the oilfield operator's influence and has therefore not been included in this method.

The cost consequences of chemical choice are manifold. These include costs of operational consequences in several dimensions, e.g. time, waste and risk. In an oil well construction operation, costs may appear under different sub-budgets. Some operational consequences are measured differently, e.g. volumes, costs, values, compliance, time, etc. In addition, cost points may be allocated to separate teams, e.g. the waste management team, drilling team, completion team, etc. However, these costs are not always evaluated simultaneously when operators make their decisions on which fluids to use in a particular well. A clear challenge is how to compare different types of chemical impact, e.g. health versus environment, and relate these directly to costs. Here, EMA principles of accurate accounting for effects provide a natural framework for ensuring all relevant data are captured and accounted for.

The objective of the research described is to provide a solution to these challenges and enable inclusion of environmental- and health-related accounting principles in oil well planning stages, across sub-budgets and the overall project period. The aim is to facilitate identification of the most operationally efficient HSE oil well construction fluid. The overall aim is to create a comparative tool that allows the influence of the chemicals hazard profile on the overall cost of oil well construction projects to be routinely included in the planning process. The objective is to enable oil company asset managers and engineers in charge of oil well projects to consider overall operational aspects and comparative HSE risk of fluid alternatives in a systematic and repeatable manner. The following targets were set for the project:

- Construct a supporting framework, which allows the collation of overall operational cost points and supports direct comparison of chemicals with different pricing models.
- Define a model for comparing chemical HSE risk covering the entire chain of operations and including consideration of the operator's incident expectancy.
- Convert chemical HSE risk and health and environmental consequences into a cost figure in a consistent and transparent manner taking into account both tangible and intangible costs and reflecting the cost of legal requirements, liability trends and locational differences.
- Implement an Excel-based operational tool that allows a fast and comparative assessment of overall cost and HSE consequences of choosing a particular fluid.

In this first version of the model the emphasis is put on completion of the oil well through the construction operation. The boundaries for the system are created by including the completion operational phase, the immediately preceding phase and the post-completion phase. Operational parameters with clear costs related to the choice of fluid can be divided into technical performance, future productivity and immediate HSE-related consequences. Technical performance of a fluid is stringently evaluated as a first step in the decision-making process. Only technically suitable fluids can be considered further. This step has therefore not been included in the developed model. The benefit from the fluids in the completion of the oil well construction process and future productivity are also influenced by how the oil well is constructed. Nevertheless, the assessment of the magnitude of influence that any particular parameter has on future productivity is highly subjective and has therefore not been included here. In summary, the focus is on allowing comparative cost and HSE assessment of fluids that meet technical performance criteria in relation to the overall customer benefit from a completed technical project.

The development work included a review of monetization of HSE principles, incident rates, risk-cost accounting and risk assessment methods. The relevant operational parameters to take into account are developed through an extended and iterative round of interviews and workshops for engineering and management personnel from several oil companies and a chemical supplier. The supporting tool was developed in stages: an original simple prototype was refined and extended to cover the entire chain of operational events after incorporating feedback received from potential end-user groups. Input was sought from operators, field engineers, oil well designers and fluid manufacturers. The team working on the model has expertise in risk management, economic modelling, eco-toxicology, HSE and statistics.

3 The Methodological Framework Used in the Modelling

The overarching aim of an oil well construction project is to optimise profitability by delivering a high value oil well at lowest cost and risk. A contributing factor to the overall value created by such a project is the prudent management of HSE aspects and risks (Clare and Armstrong 2006, Kuijper et al. 2006, Spence and Emmons 2002). The developed methodology described in this chapter comprises both environmental and social aspects of EMA or sustainability management accounting that is used for the same purpose (see e.g. Schaltegger et al. 2006), as well as both physical and monetary accounting (Burritt et al. 2002). The operational HSE cost-efficiency approach adopted follows eco-efficiency principles (see e.g. Verfaillie and Bidwell 2000) and is similarly comparative although there are some important differences, i.e. it does not take into account the overall life cycle of the products used but is aimed at accounting solely for overall project operational and HSE costs. Neither have any attempts been made to rank overall environmental impacts. However, by accounting for HSE costs, the method facilitates identification of how to avoid such costs by making them visible and raising the focus on preventing occupational accidents (see Rikhardsson 2006). Relevant users for the methodology are the marketing and sales department of the fluid manufacturer for providing a means by which buyers can easily evaluate the overall cost prediction of using the products, i.e. better HSE information. The other group of users are engineers, HSE experts and purchasing officers (Burritt et al. 2002).

The basic principle for calculating operational expenditure (OPEX) is a standard approach used by management (e.g. Williams et al. 2006). Assessments of overall operational expenditure that can be directly related to chemical choice has, however, rarely been used to identify the most cost-effective chemical for an oil well construction operation. There are both practical and organisational reasons for this. Firstly, management of many oil and gas exploration projects is organised around several technical discipline-related budgets. This has caused certain consequences to de facto be paid by "someone else's budget" which clearly has hampered consideration of overall operational costs to be noted as an input to the fluid decision. Secondly, linking the more remote consequences, e.g. waste costs from the production phase, to the initiating source, e.g. oil well construction chemical, and to the consequences for practice requires cross departmental discussions between groups of people who may not normally meet. Nevertheless, optimisation of operations and minimisation of HSE impacts, whilst maximising company profits, requires an overall view of the cost structure of chemical choices. The model development work therefore has been focused on combining and adapting existing methods from management, risk assessment, eco-efficiency analysis and EMA within a single framework.

By modelling an overall framework for all relevant data inputs, the method becomes of practical use. The overall methodological framework is based on tailoring well-known financial analysis tools to a HSE framework. Inclusion of all the relevant data points and calculations in a single tool requires careful analysis of the types of data available from the project team and which parameters influence the

OPEX related to chemical use. The results are then related to existing costing methods and analysed from the view of their practical constraints.

Total cost of ownership (TCO, also known as total cost of operation) was identified as a potential method (see e.g. Ellram 2006). In TCO, the indirect costs such as maintenance, floor space, security breaches, etc., as well as direct costs, are allocated to total system costs. The structure provides a good basis for identifying the various cost items to take into account but the fundamental focus of TCO is on costing the maintenance of a service infrastructure with a certain service level. Therefore, TCO is readily adapted to the type of projects considered.

Activity-based costing (ABC) (Kaplan and Atkinson 1998, Kaplan and Bruns 1987) is identified as a second possible framework. The basic idea of ABC in identifying the cost drivers that trigger various activities (see Fig. 14.1) allows activity-related indirect costs to be identified and assigned or allocated to products or services (cost objects). Activities in the case of chemical selection and usage would include onshore transport, storage, shipping, use and waste handling (Gilbert et al. 2009).

An activity-based approach has been popular in health and safety accounting to bring the cost of occupational accident prevention into focus. The centre of the activity-based approach is the causality chain between the accident and consequences of the accident which are then valued in economic terms (Rikhardsson 2006). From a management perspective, ABC has been criticised for its focus on operational cost analysis rather than analysing the return on investment or economic value added. However, as there is no reliable method that indisputably links chemicals used with the overall oil well productivity, this therefore rules out more detailed analysis of return on investment in practice. In relation to chemical choice, the ABC operational cost focus is particularly well received (Gilbert et al. 2009).

Cost, as related to chemical use in oil well construction, is a relatively independent activity and can be divided further into separate sub-activities that trigger costs at a system level that logically fit within the engineering activities framework. In the oilfield industry, oil well construction chemicals are usually bought or sometimes rented as part of an overall service, where the running of the fluid is provided as part

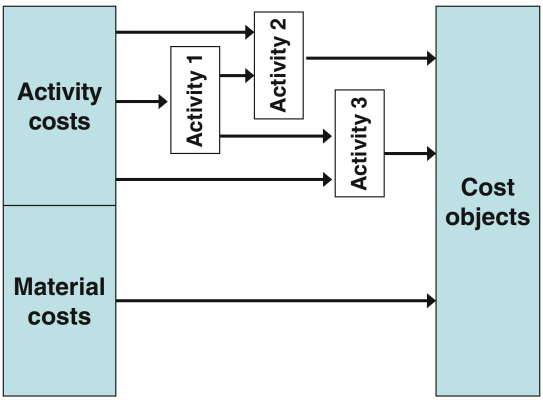

Fig. 14.1 A simplified view of ABC activities for chemical selection and usage

of an arrangement which simplifies the overall cost point structures for the operator. For management of engineering projects, where chemicals play a fundamental role, ABC provides a natural framework for the user to identify, allocate and quantify both direct OPEX and indirect HSE-related costs. ABC also provides a logical basis for understanding why costs arise allowing management approaches such as activity-based management (ABM) to be applied (Kaplan and Bruns 1987).

The framework for supporting data collation and calculations was developed iteratively in conjunction with users. The costs of operational phases were only assessed where the choice of fluid influences cost. These cost points were identified through sessions with operational personnel and defined as waste, transport, time, losses related to waste handling and additional process or material requirements. The activities were analysed to work backwards towards the initial source of the cost. The entire process was broken down into separate activity-related steps. Each activity was analysed to define and understand which consequences relate to the HSE hazard; such costs were analysed and separate calculations constructed for each consequence. For example, permits to discharge waste water are generally dependent on the level of hazardous components present in the water. Completion fluids that have seeped into the formation may filter back into the water over an extended time, and the degree of hazard posed by the fluid constituents will affect the hazard level associated with the water actually used in future. Hence, the cost triggered by using a fluid that contaminates the waste water beyond acceptable hazard discharge limits in an offshore operation will be related to treating and/or shipping the waste water back to shore for disposal.

The framework construction was completed by grouping individual variables and cost calculations into four cost types: direct fluid costs, operational costs of using fluid, normal operational HSE costs and the costs of HSE-related risk. The risk potential is arrived at through estimating cost-at-risk (CaR), an adaptation of the value-at-risk (VaR) approach (Gilbert and Kumpulainen 2008). This is depicted in Fig. 14.2.

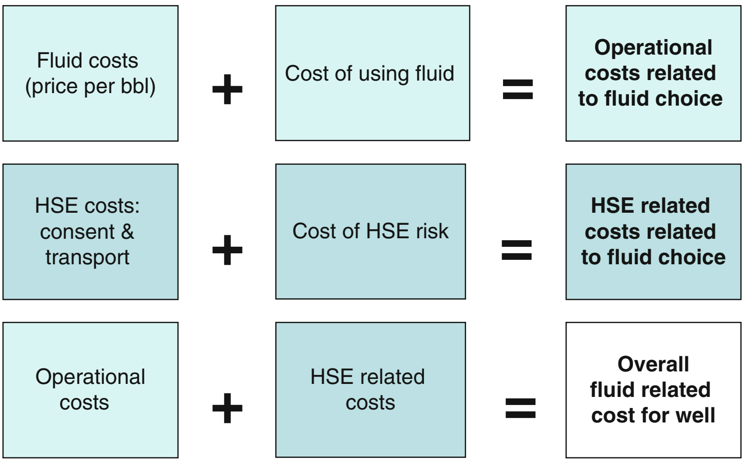

Fig. 14.2 Cost types and the overall calculations for oil well fluid (Gilbert and Kumpulainen 2008)

As the objective of the overall study is to create a tool that facilitates data input into an EMA accounting model that supports pre-operational budgeting, emphasis is placed on developing the model and defining the input in as relevant and easy a way to understand as possible. A detailed discussion about the required inputs is available in previous papers (Gilbert et al. 2008b, 2009). To facilitate input in many units, conversions, i.e. from volume and hazard of waste to cost, were included in the model. For the users, the model allows input of easily quantifiable starting points that are then used to calculate the overall end costs.

4 Bridging Operational Aspects to HSE

4.1 Comparative Chemical HSE Risk Assessment

HSE risks related to chemical use and discharge are recognised and prioritised through (Gilbert et al. 2008c): (1) in-house corporate HSE risk management targets, policies and procedures; and (2) risk evaluation and reduction to meet external regulatory consent conditions.

Detailed risk assessments allow more informed decisions but are time consuming, require specific expertise and seldom include considerations of cost. Based on confidential operator interviews it seems that detailed comparative risk and cost of risk assessments to support particular purchasing decisions are relatively rare in the oilfield industry. Risk assessment underlying the decision model presented in this paper is based on some fundamental assumptions and simplifications regarding risk potential, uncertainties, probabilities and consequences (Gilbert and Kumpulainen 2008, Gilbert et al. 2008b).

To have an impact on chemical choice any method of assessment must be easy to use and the result reflective of the company's experience of risk. To facilitate inclusion of risk without statistical uncertainty, a scenario-based approach with open inputs of expected incident frequencies was adopted. The consequences of unwanted incidents were calculated based on fluid hazard properties. Consequences to humans, the environment and society, in the form of liabilities, were included.

4.2 From HSE to Cost

Guidelines for how to monetise HSE risk have, amongst other things, been published by the United States Environment Protection Agency (USEPA) (US EPA 1996). The USEPA lists issues which should be taken into account when considering overall cost of using a particular technique or chemical and these are used as a basis for identifying all relevant end costs, including those related to compliance, remediation obligations, non-compliance-related costs and costs to society such as obligations to pay for damage to natural resources (Gilbert and Kumpulainen 2008).

The HSE-related costs that are relevant in identifying the most cost-effective chemical for oil well construction are: (1) cost items related to normal operations, including requirements for consents and accident prevention – these differ based on the hazardous nature of the chemical; and (2) cost of HSE risk, which will only be realised if an incident occurs. The cost is directly related to the magnitude of incident consequences. The magnitude of consequences is determined by assessment of how hazardous the chemical is to humans and the environment.

The first type of cost is relatively easy to estimate through the logistics chain (see also Gilbert and Kumpulainen 2008). The cost of risk is more complex to compute. There are several methods for costing health and environmental consequences (e.g. Bennett et al. 2003, Dixon 1998, IFAC 2005, Rikhardsson et al. 2005, UNDSD 2001, US EPA 1996). The inclusion of intangible values is particularly difficult when it comes to absolute assessments (IFAC 2005, Rikhardsson et al. 2005). The cost of consequences of risks to humans and the environment can reliably be measured in money terms *only* through directly incurred costs, such as environmental restoration and hospitalisation, and either estimated in advance or measured post-event. However, intangible values (e.g. natural beauty, human life, pain cannot be ignored). In order to take these into account yet avoid potential value discussions in relation to each cost point, the following decisions were taken for the construction of the method: (1) only direct cost items are directly priced; and (2) intangible factors are taken into account through a weighting of direct costs incurred. The weighting is defined by the operator and based on the relative value given to HSE aspects. Health and environment are given separate weighting factors. The range of the weighting factors is from one to five. Direct HSE-related costs are multiplied by the weighting factor and the total represents the sum of direct and intangible costs (Gilbert et al. 2008a). The overall approach to calculating risk cost is depicted in Fig. 14.3.

This method is adopted from management decision-making where the use of weighting factors in assessing options is common (Teale et al. 2003). The cost of risk is calculated simply by multiplying realistic incident frequencies, as set by the operator, by the cost of consequences. The cost of consequences of release incidents

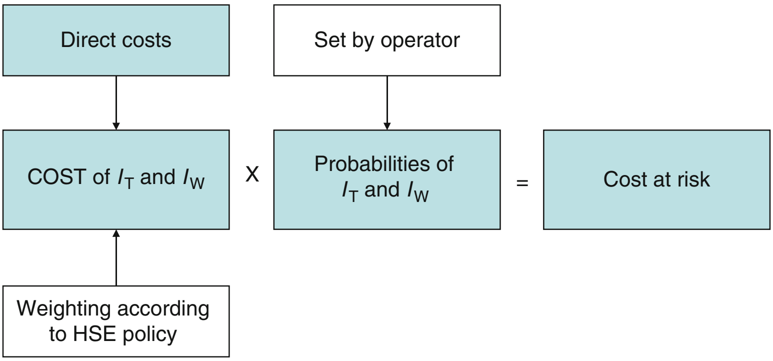

Fig. 14.3 Costing HSE risk (I_T = incident with minor, typical consequences; I_W = incident with major, worst case consequences) (Gilbert and Kumpulainen 2008)

includes the cost of direct consequences, both HSE and operational, and potential legal costs. The scenario costs are then summed to give the predicted cost of HSE risk per oil well.

5 Implementing the Approach in the Excel Tool to Support Practical Decision-Making

5.1 Introduction of the Two Case-Study Chemicals

Oil well completion fluids are solid-free brines introduced into the oil well to provide control while the oil well is prepared for production. Completion fluids are used in large volumes (1,500–3,000 bbl per oil well is typical). The nature and toxicity of the waste created during a completion operation is linked to the property of fluids. For oil wells that are highly pressurised there are two alternatives: caesium formate and zinc bromide both high-density brines. These brines have profoundly different pricing and HSE properties making this an ideal case for assessing the overall impact of chemical choice.

Caesium formate is a comparatively expensive fluid with a relatively benign HSE profile. Zinc bromide has a more hazardous HSE profile and comes at a considerably lower price per unit. A comprehensive comparative study of the HSE properties of caesium formate and zinc bromide was undertaken in 2007 and subjected to peer-review (Gilbert and Pessala 2007). The results are briefly summarised in Table 14.1.

The pricing models between the two chemicals differ in that caesium formate is rented to the user and losses of the material are strictly controlled. Zinc bromide is

Table 14.1 Summarised HSE profiles of the case chemicals

Hazard receptor	Caesium formate	Zinc bromide
Human health	Significantly less hazardous alternative. Skin irritant after extended contact. May harm the eye. Weak potential for inhalation and ingestion effects.	Highly corrosive: causes severe chemical skin burns, necrosis and extensive eye damage. Several incidents reported in the literature (e.g. Saeed et al. 1997, Sagi et al. 1985, Singer et al. 1992). Potential inhalation and ingestion effects may cause significant damage.
Safety	No specific safety hazards, high pH may be incompatible with certain materials.	The corrosiveness of zinc bromide requires more specialist equipment during storage, handling and transport.

(continued)

Table 14.1 (continued)

Hazard receptor	Caesium formate	Zinc bromide
Marine environment	Significantly less toxic than zinc bromide both short-term and long-term. Results from environmental surveys following formate discharges support this conclusion (Zuvo et al. 2005).	The toxicity of zinc bromide to marine and brackish water species is at least two orders of magnitude higher than that of caesium formate. In the freshwater environment the difference is less marked. The zinc ion has the potential to cause long-term chronic effects in organisms. Exposure to even small amounts of zinc (<1 mg/l) has resulted in inhibition and disturbance of, for example, growth (e.g. common mussel) (Strömgren, as quoted in WHO 2001) and reproduction (e.g. sea urchins) (Dinnel et al., as quoted in WHO 2001) in laboratory conditions. In the long term, such effects may result in highly disturbed biotic communities in the environment.
Terrestrial environment (dilutive effect of sea water absent)	Large single point exposure causes mortality of soil microbes, plants, etc. The spatial extent of most severely affected area (all organisms dead) significantly smaller than with zinc bromide. The acute toxicity significantly lower compared to zinc bromide.	Large single point exposure causes mortality of soil microbes, plants, etc. The spatial extent of most severely affected area (all organisms dead) significantly larger than with caesium formate. The acute toxicity significantly higher compared to caesium formate. Even relatively small discharges will cause detrimental effects. Toxic effect in aquifers and ground water.

cheaper and in general sold directly sometimes including a buy back agreement of returned fluids. The comparative cost difference for outright sales for caesium formate can be several times higher than zinc bromide.

5.2 The Fluid Tool

To enable practical use of the model a supporting tool, BrineWise™, was developed. This Excel-based tool is constructed to provide a systematic and logical approach to capture all relevant cost elements from different budgets and calculate the overall costs related to fluid choice. The framework fully supports location- and operation-specific input and takes into account corporate values and operators' risk expectancy/risk aversion. The tool facilitates practical application of overall fluid-related costs in the planning stage. The tool itself has been constructed in three parts (Gilbert and Kumpulainen 2008).

1. *Direct fluid cost*: These are simply the costs of fluid purchase or rental, and fluid losses.
2. *Operational costs*: Collating and calculating the cost of transport, time delays, waste-related cost and including consideration of waste costs incurred during the phase after completion, i.e. the production phase, where production delays may cause significant costs, or where waste water contaminated with the completion fluid may require containment. The tool also includes normal HSE-related operational costs. The direct operational consequences are arrived at from a step-wise consideration of the operations and the different variables dependent on the fluid HSE properties. The model is based on ensuring that each of the variables can be specified for a particular operational environment.
3. *HSE risk costs*: Assessing the cost at risk from HSE-related incident potential. The HSE data input requirement includes consideration of HSE weighting and risk frequencies. The cost of HSE risk is calculated as a function of direct costs based on the effect on humans and the receiving environment as well as potential material and time losses. There are four risk scenarios included in the tool: road, storage, shipping and use. The risk scenarios also include consideration of potential legal costs and societal costs.

The HSE and risk data are linked to regional requirements and only require input once in each region such as North Sea or Gulf of Mexico. To calculate the overall fluid cost only requires input of direct variables related to the specific operation, such as how much fluid is used, the cost of the fluid, expected waste volumes, etc. The approach gives management a fast and user friendly way of including overall EMA and societal accounting principles rapidly and reliably. The results are presented on a summary page where the relevant values are compared for each fluid. Three cost results are presented: (1) cost of using the completion fluid, including fluid purchase cost; (2) cost at risk; and (3) average predicted cost for the oil well.

The tool is simple to use and can be used without new software downloads or extensive training. Tool functions are implemented through simple navigation buttons, input cells and drop down menus. In Fig. 14.4, an example of the HSE-related cost data page is shown (cells are input cells or drop down menus for choosing yes/no, here populated with example values).

Figure 14.5 shows a screenshot of the tool result page, populated with example values derived during interactive work sessions for specific wells.

The results are also presented graphically to enhance comprehension (see Fig. 14.6).

HSE POLICY AND RISK FREQUENCIES		
Health weighting factor	1	1 to 5
Environmental weighting factor	1	1 to 5
Incidents with small to average HSE consequences	1/5	
Incidents with larger than average HSE consequences	1/100	

AVERAGE DIRECT COSTS PER PERSON FROM INJURIES		
Loss of productivity / employee day rate	2 000	US$/day
Hospital transport from onshore incident	415	US$
Hospital transport from offshore incident (helicopter)	8 000	US$
On-site medical treatment (for injured persons who dont need to be hospitalised)	600	US$
Hospital treatment (includes on site treatment for hospitalised persons)	1 200	US$/day

ENVIRONMENTAL RESTORATION COSTS		
Mobilization of excavation equipment (contamination)	5 000	US$
Excavation cost (per m3 of soil)	10	US$/m3
Transport of contaminated soil	120	US$/m3
Site restoration on land (soil replacement, planting…)	22	US$/m3
Site restoration (waterways, aquatic)	425 000	US$
Site restoration / compensation to private landowners	1	US$/m2

FLUID HSE HAZARD RELATED OPERATIONAL DATA			
Average cost of fluid onshore transport		4.20	US$/tn
Average cost of fluid shipping		80	US$/tn
	Cesium Formate	Zinc Bromide	
Hazard factor for land transport (TDG classification)	No	Yes	yes/no
Hazard factor for marine transport (IBC ship code classification)	3	2	3 or 2 or 1
Comparative onshore transport cost (based on hazard factor)	4.20	4.41	US$/tn
Comparative shipping cost (based on hazard factor)	80	88	US$/tn
Personnel requiring PPE (in addition to standard rig requirements)	0	8	persons
Cost of additional PPE	2 000	2 500	US$
Cost of contaminated soil / solid waste treatment and disposal	200	1 000	US$/m3
Cost of liquid waste treatment and disposal	15	175	US$/bbl
Classified as hazardous waste	No	Yes	yes/no
Availability of reclamation and recycling process for spilled fluid	Yes	No	yes/no
Cost of the reclamation and recycling process	5	5	US$/bbl

THRESHOLD TOXICITY VALUES FOR LAND / AQUATIC LIFE RESTORATION	Cesium Formate	Zinc Bromide	
Chemical concentration in **soil** for land restoration	5 000	50	mg/l
Chemical concentration in **freshwater** for minor restoration of aquatic life	50	1	mg/l
Chemical concentration in **freshwater** for major restoration of aquatic life	1 000	5	mg/l
Chemical concentration in **brackish water** for minor restoration of aquatic life	100	1	mg/l
Chemical concentration in **brackish water** for major restoration of aquatic life	500	5	mg/l
Chemical concentration in **sea water** for minor restoration of aquatic life	100	1	mg/l
Chemical concentration in **sea water** for major restoration of aquatic life	1 000	10	mg/l

Fig. 14.4 Screenshot of a HSE administrative cost page in BrineWise™ (values are for illustrative purposes only)

6 Discussion

When deciding about the chemicals to use in an oil well construction operation, cost consideration often stops at a basic comparison of fluid costs per barrel. However, different chemicals create different costs and consequences over a range of processes. This means there is a need to include the chemical OPEX and the cost of risk in the decision-making process. The impact of HSE-related costs and risks can be high.

To bridge the current gap between consideration of chemical alternatives, overall oil well construction cost and HSE consequences, there was a clear need for a unifying method and supporting tool. The model described here provides decision-makers, engineers and HSE experts with a common language and common platform to assess the overall consequences of a fluid choice rapidly and without the need of external expertise. User feedback indicates that it is a simple and reliable way of

FLUID AND OPERATIONAL COSTS	Cesium Formate	Zinc Bromide	Currency
Cost of fluid (before losses)	604 197	104 563	US$
Cost of lost fluids	163 483	99 584	US$
Onshore transport	1 200	1 260	US$
Shipping	22 856	25 142	US$
Personal protection	0	20 000	US$
Suboptimal rig time	0	0	US$
Delay in production	444	740	US$
Fluid related other operational costs	51 000	115 800	US$
Total waste fluids, ship to shore	0	213 991	US$
Produced water treatment on rig	18 000	0	US$
Waste disposal	0	175 000	US$
Cost of brine, contaminated production stream	105 200	226 500	US$
Other, please specify			US$
Other, please specify			US$
Total operational costs	**966 380**	**982 580**	**US$**

COST OF RISK	Included in comparison	Cesium Formate		Zinc Bromide		Currency
		20%	1%	20%	1%	
Scenario 1 type incidents (ROAD)	Yes	11 172	343 928	390 593	3 955 656	US$
Scenario 2 type incidents (STORAGE)	Yes	4 243	1 096 721	107 197	3 887 670	US$
Scenario 3 type incidents (SHIPPING)	Yes	17 918	159 756	357 717	2 314 815	US$
Scenario 4 type incidents (RIG)	Yes	69 478	1 291 560	383 235	2 874 975	US$
Average cost of incident consequences		**25 703**	**722 991**	**309 685**	**3 258 279**	**US$**

COST SUMMARY	Cesium Formate	Zinc Bromide	Currency
Operations as planned (79 % of wells)	966 380	982 579	US$
Operations outside planned (small to average HSE consequences, 20 % of wells)	992 082	1 292 265	US$
Operations outside planned (larger than average HSE consequences , 1 % of wells)	1 689 371	4 240 858	US$
Average cost per well	978 750	1 077 099	US$
Additional cost, which is at risk to occur during WC (with small to average incident confidence 20 %)	25 703	309 685	US$
Additional cost, which is at risk to occur during WC (with larger than average incident confidence 1 %)	722 991	3 258 279	US$

Fig. 14.5 Screenshot of the results page in BrineWise™ (values are for illustrative purposes only)

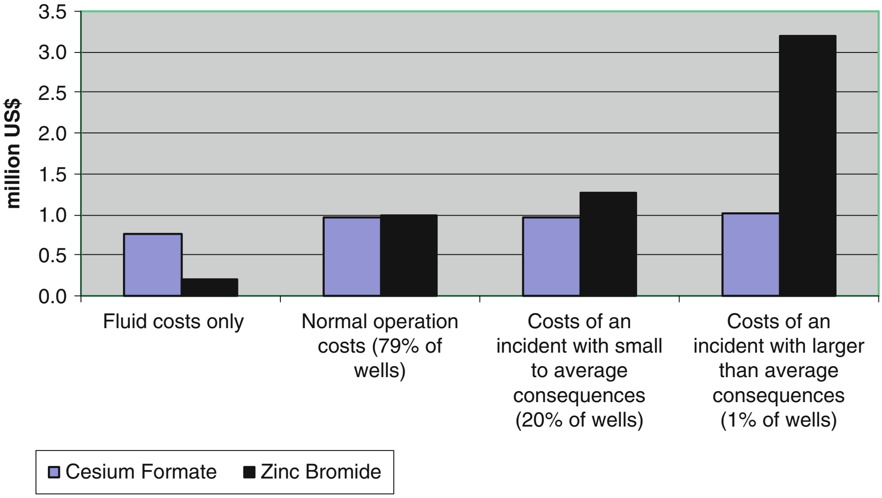

Fig. 14.6 Screenshot of the results page in BrineWise™ (values are for illustrative purposes only)

estimating overall costs of chemical choice. As a consequence, one of the major oil and gas companies has implemented the approach for their in-house fluid decision-making software from where it is available to all engineers globally.

Whilst not reaching the level of detail of a thorough EMA or eco-efficiency study, it would nevertheless appear that considerable benefits could be had by taking this type of approach as a part of the HSE assessments incorporated in the planning process. Whilst the input data for the tool has been carefully selected to be easy to use for engineers in management positions, it would appear that the barrier to establish data input from “somebody else’s budget” still hampers wider use of the tool. Setting the overall HSE costs to reflect accurate data rather than default example data from the literature would be better suited to HSE professionals or environmental management accountants. For HSE professionals, cross-departmental work is the norm and it may be that this would be the best target group for users of the tool.

The results are highly relevant not only to the project management team but also to corporate policy makers in giving a fast and reliable way to include eco-efficiency criteria in the decisions on chemical use. From test cases based on data suggested by the engineers from oil and gas companies, the less hazardous fluid, but more expensive in absolute terms, appears either more cost-efficient or highly competitively priced in many circumstances. However, real data on using the tool for planning cannot be analysed publicly as these data are confidential to the operator.

The main benefits from applying the model to choosing the most cost-effective chemical in oil well completion operations can be divided into HSE benefits and management benefits. The HSE arguments for adapting the model can be summarised as:

- Enable corporate HSE policy to be translated into practice and take into account HSE values of companies through weighting.
- Ensure that realistic risks are taken into account based on company experience and risk aversion through setting risk frequencies that reflect reality.
- Allow HSE to be taken into account in a comparable manner across the globe.
- Implement EMA principles into project planning and budgeting.
- Enable a partial eco-efficiency analysis to be carried out on high volume chemicals.

From a management and engineering point of view, arguments for using the approach include:

- Allows systematic yet fast overall comparisons of costs and risk-related to fluid options
- Utilises real operational data and is directly applicable as input to decisions
- Avoids complex value arguments and allows HSE to be taken into account on par with other costs in an easy, tangible and transparent way

The drawbacks of the method lie in the simplification of HSE aspects. Where two chemicals with widely differing HSE properties are considered, the results are clear cut. However, when applying the method to chemicals with less differentiated HSE properties, it may not be powerful enough to differentiate sufficiently between the options. The approach does not allow an analysis of differences between suppliers in the chain. Another potential drawback occurs if the risk scenarios do not reflect real risk potential. It is therefore considered vital that when the tool is first used by any operator, the risk scenarios as well as the legal consequences and HSE costs are systematically scrutinised and amended to provide a best selection of risks to be considered. However, the largest relative advantage from an overall HSE point of view is the substitution of the most hazardous chemicals with benign alternatives.

7 Conclusions

To make informed decisions an overall understanding of the consequences of the decision is required. The value and importance of expert HSE assessments and detailed post-operational EMA analysis is undisputed. However, the value of the model and tool presented lies in extending HSE and EMA principles to chemical choice by making these accessible and easy to use for the people who actually make decisions during the planning stages. The approach and the tool described in this paper represent a significant advance in making EMA principles accessible for everyday decisions in the oilfield industry. The comparative approach enables managers and engineers to rank options and minimise cost and risk through choosing the most cost-efficient chemicals with the lowest HSE risk. The tool improves profitability and reduces liability in oil well construction operations by pointing operators to chemicals that reduce risk and minimise overall expenditure. Whilst the approach has been designed to select the most cost-efficient oil well completion fluid, the overall framework has since been extended to cover other oil well construction chemicals for one of the largest oil and gas companies[1].

The approach and tool presented provide a means to cover and assess the various operational and incident-related costs in a systematic manner. The model allows input by different cost centres in an asset team and facilitates the combination and summarisation of different cost elements. The operator is the ultimate benefactor of this practical process of bridging the gap between cost, operational choice, HSE and risk.

[1]Confidential work, not reported in the literature

References

Bennett M, Rikhardsson P and Schaltegger S (editors) (2003) *Environmental Management Accounting: Purpose and Progress* Dordrecht, Kluwer Academic Publishers

Burritt RL, Hahn T and Schaltegger S (2002) Towards a comprehensive framework for environmental management accounting – links: between business actors and EMA tools *Australian Accounting Review* 12.2 39–50

Clare J and Armstrong L (2006) Comprehensive risk-evaluation approaches for international E&P operations *SPE Projects, Facilities and Construction* 1.3 1-6 SPE-98679-PA

Dixon J (1998) *The Economic Valuation of Health Impacts*, The World Bank [online] [accessed on 1 Sep 2008]. Available from Internet URL <http://siteresources.worldbank.org/INTEEI/214574-1153316226850/20486375/EconomicValuationofHealthImpacts1998.pdf>

Ellram L (2006) Total cost of ownership: elements and implementation *Journal of Supply Chain Management* 29.4 2–11

Gilbert Y and Kumpulainen A (2008) Bridging HSE risk with cost analysis: a model for optimising completion fluid choice *SPE Middle East Heath, Safety, Security, and Environment Conference and Exhibition*, 20-22 October Doha, Qatar, SPE paper 120531

Gilbert Y, Kumpulainen A and Pessala P (2008a) *BrineWise User Manual* United States, Cabot Speciality Fluids.

Gilbert Y, Kumpulainen A, Pessala P and Raivio T (2008b) HSE risk monetization and well construction fluids: presenting a method for comparing the costs associated with operations and HSE risk *Association of American Drilling Engineers (AADE) Conference Paper*

Gilbert Y, Kumpulainen A and Syrjänen M. (2009) New tool assists informed purchasing decisions based on overall cost and HSE risk potential of well construction fluids *SPE Americas E&P Environmental and Safety Conference*, 23-25 March San Antonio, Texas SPE paper 120488

Gilbert Y, Nordone A, Downs J, Vaahtera A, Pessala P and Raivio T (2008c) REACH and the HSE case for formate brines *Journal of Petroleum Technology* August 81-83

Gilbert Y and Pessala P (2007) *Cesium Formate and Zinc Bromide – Comparative Hazard Assessment and HSE Profiles* [online] [cited 21 Aug 2008]. Available from Internet URL <http://www.cabot-corp.com/cws/businesses.nsf>

International Federation of Accountants (IFAC) (2005) *International Guidance Document: Environmental Management Accounting* [online] [cited 1 Sep 2008]. Available from Internet URL <http://www.ioew.at/ioew/download/IFAC_Guidance_Env_Man_Acc_0508.pdf>

Kaplan R and Atkinson A (1998) *Advanced Management Accounting* (3rd edition) Upper Saddle River, Prentice Hall International

Kaplan R and Bruns W (1987) *Accounting and Management: A Field Study Perspective* Boston, Harvard Business School Press

Kuijper M, Stephenson M and Howard M (2006) The use of integrated decision making to embed sustainable development, *SPE Intelligent energy Conference and Exhibition* Amsterdam, the Netherlands, 11-13 April SPE 99873

Modler R and Inoguchi Y (2005) *SCUP Report Oil Field Chemicals Abstract* [online] [accessed on 21 Aug 2008]. Available from Internet URL <http://www.sriconsulting.com/cgi-bin/listoptions.pl?/SCUP/Public/Reports/OILFI000/>

Olsthoorn X, Tyteca D, Wehrmeyer W and Wagner M (2001) Environmental indicators for business: a review of the literature and standardisation methods *Journal of Cleaner Production* 9.5 453-463

Rikhardsson P (2006) Accounting for health and safety costs review and comparison of selected methods *in* Schaltegger S, Bennett M and Burritt R *Sustainability Accounting and Reporting* Dordrecht, the Netherlands, Springer 129–151

Rikhardsson P, Bennett M, Bouma JJ and Schaltegger S (editors) (2005) *Implementing Environmental Management Accounting: Status and Challenges* Dordrecht, the Netherlands, Springer

Saeed WR, Distante S, Holmes JD and Kolhe PS (1997) Skin injuries afflicting three oil workers following contact with calcium bromide and/or calcium chloride *Burns* 23.7-8 634-637

Sagi A, Baruchin AM, Ben-Yakar Y, Kon M, Eyal A and Mahler D (1985) Burns caused by bromine and some of its compounds *Burns* 11.5 343–350

Schaltegger S, Bennett M and Burritt R (editors) (2006) *Sustainability Accounting and Reporting* Dordrecht, the Netherlands, Springer

Singer A, Sagi A, Ben Meir P and Rosenberg L (1992) Chemical burns: our 10-year experience *Burns* 18.3 250–252

Spence S and Emmons L (2002) Integrating HSE in design: Implementing a simple structured process, *SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production*, 20-22 March Kuala Lumpur, Malaysia, SPE 73901

Teale M, Currie D, Dispenza V and Flynn J (2003) *Management Decision Making: Towards an Integrative Approach* Harlow, Pearson Education Limited

United Nations Division for Sustainable Development (UNDSD) (2001) *Environmental Management Accounting Procedures and Principles* New York, United Nations

US EPA (1996) *Valuing Potential Environmental Liabilities for Managerial Decision-Making: A Review of Available Techniques* (EPA 742-R-96-003) Washington D.C., United States Environment Protection Authority

Verfaillie HA and Bidwell R (2000) *Measuring Eco-Efficiency – A Guide to Reporting Company Performance* [online] [cited 1 Sep 2008]. Available from Internet URL <http://www.wbcsd.org/web/publications/measuring_eco_efficiency.pdf>

WHO (2001) *Environmental health criteria 221: Zinc* Zurich, World Health Organization

Williams J, Haka S, Bettner M and Carcello J (2006) *Financial & Managerial Accounting* (14th edition) Boston, McGraw-Hill Higher Education

Zuvo M, Bjornbom E, Ellingsen B, Buffagni M, Kelley A and Trannum HC (2005) High-resolution environmental survey around an exploration well drilled with formate brine in the Barents Sea, Norway, *SPE/EPA/DOE Exploration and Production Environmental Conference* (7-9 March 2005) Galveston, TX

Chapter 15
Sustainability Management Control

Stefan Schaltegger

Abstract Sustainability issues create business opportunities and threats. Based on a discussion of drivers to create a business case for sustainability, this chapter argues for a more systematic approach to management than current approaches that in practice involve working with checklists. Given the core logic behind the sustainability balanced scorecard (SBSC) perspectives, a concept for sustainability management control is proposed.

Keywords Sustainability management control • Sustainability balanced scorecard • Sustainability accounting • Key performance indicators • Performance drivers

1 Introduction

Sustainability has become a driver for both business risks and business opportunities. Strategic management and information management are thus challenged to take into account sustainability information.

Independent of the strength of their influence, elements of sustainability can work through market or non-market processes to have an effect on business success. This chapter argues for a structuring concept for sustainability management control that is based on the sustainability balanced scorecard approach and accounts for both market and non-market factors that can influence business success. The sustainability management control approach provides an indication of how to structure key performance indicators and information management for corporate sustainability.

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2 Market and Non-market Character of Strategically Relevant Social and Environmental Topics

Environmental and social topics offer both corporate risks and business opportunities (e.g. Esty and Porter 1998, Holme and Watts 2000, Lankoski 2006, Porter and van der Linde 1995b, Schaltegger and Synnestvedt 2002). Independent of the strength of influences on companies, these topics can exert a visible, economic relevance or they can have a non-market character (Fig. 15.1).

In order to be able to take into account the relevance of elements of sustainability to business success in a systematic way, a variety of characteristics and processes of market and non-market factors must be considered. Costs for carbon dioxide (CO_2) emission certificates, declines in sales of products thought to be socially questionable or savings in energy costs through more efficient production processes are obvious examples of market processes. There are many environmental and social issues, however, that operate indirectly. Laws and regulations, social trends and political processes may change suddenly or over a period of years leading to, amongst other things, increases in costs or to an increased willingness on the part of consumers to pay higher prices (e.g. Holme and Watts 2000, Schaltegger and Wagner 2006).

Consumer attitudes and behaviour, for example, reflected in the fact that genetically modified food is not purchased in most Western European countries, can be identified with market research and is mostly dealt with by conventional marketing approaches. Costs are saved because of the reduction of materials and energy in

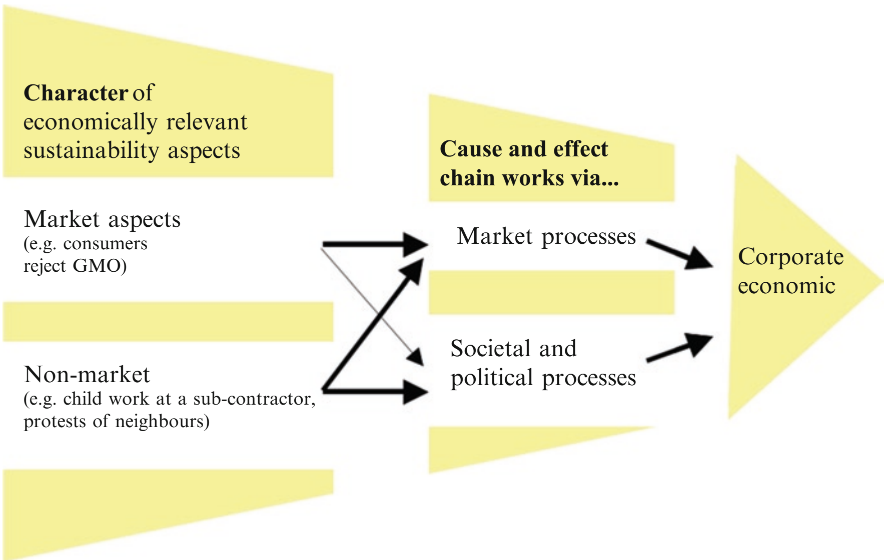

Fig. 15.1 Market and non-market character of economically relevant sustainability topics

production (e.g. von Weizsäcker et al. 2009) and are expressed in the accounting systems and can influence economic performance of the company.

As a contrast to these market-driven sustainability issues, many environmental and social topics develop outside of markets in the regulatory and societal business environment (e.g. Freeman 1984, Schaltegger et al. 2003:36). For instance, child labour at sub-contractor level does not have a direct link to costs or revenues. Nevertheless, neither a direct contact with the children nor the subcontractor is necessary to give the sustainability issue 'child labour' economic relevance for a leading brand company in the supply chain. As Nike, the world's largest sports article manufacturer has experienced, non-market topics can suddenly become economically relevant through lower sales and reputation when non-government organisations (NGOs) address the topic and attention is given by the media. In some cases these non-market issues can have a stronger economic effect than many issues with a clear market link.

In addition to the differentiation between market and non-market issues, a distinction between market and non-market processes is helpful. Non-market processes can be societal processes driven by media or in social communities on the Internet which can have a large influence on values and social attitudes towards companies and products (e.g. Massey 2001). They also include actions of regulators (e.g. Hemphill 1997) and public administration, such as restricting daily flight times by reacting to protests of neighbours of an airport against noise outside normal hours.

Influences of market changes on political developments and regulations are mostly less relevant to business, however, they still exist. An example of such a development is the increasing European Union regulatory activity on genetically modified organisms even though these products are not purchased to a significant extent in Western Europe.

This interplay between company management focused on the semi-closed system of the corporate organisation, and more open systems characterised by market processes and the even broader system of society characterised by market and non-market processes, is reflected in the principle of equifinality (e.g. Doty et al. 1993, Gresov and Drazin 1997, Jennings and Seaman 1994). In closed systems, a direct cause-and-effect relationship can be drawn fairly easily. However, the analysis sketched in Fig. 15.1 calls for the consideration of sustainability issues in more open systems such as society, politics and markets. In open systems various approaches and applications are needed taking different market, political, cultural and societal contextual factors into account. Equifinality as the premise that different approaches can result in an equal result, i.e. corporate sustainability in this chapter, addresses the concept of equifinality of control and leads to the conclusion that a multifaceted management approach is useful and necessary to be effective. This chapter thus suggests developing a management approach which differentiates between varying business contexts.

As a summary, different – market and non-market – paths of influence exist where market and non-market issues influence the economic success of companies. Whereas conventional management tends to focus on market issues and market processes of influence only, sustainability management adds economic value to management by identifying, analysing and managing non-market aspects and processes in addition, and in relation, to market issues and processes. The goal for sustainability management is thus to find methodologically convincing approaches to dealing with these cause-and-effect chains (for conventional management, see e.g. Kaplan and Norton 2000). Management control constitutes one such formal approach which supports the translation of general corporate sustainability strategies into action (e.g. Schaltegger and Dyllick 2002, Weber and Schaeffer 2000). It faces the challenge of identifying both, market and non-market sustainability issues, evaluating their relevance to success and supporting management in its decision-making and action-taking.

3 Relevance of Sustainability to Corporate Success

The starting point for an effective management of elements of sustainability relevant to business success is an understanding of their interrelationships. There are however two essentially different opinions about the effects of voluntary environmental and social measures on economic success. There is the idea that environmental and social activities that go beyond complying with the law only cause additional costs and thus conflict with the goal of economic success (e.g. Bhimani and Soonwalla 2005 discuss a continuum of effects). This view assumes that every environmental and social activity reduces economic success. Examples given in this context are typically end-of-the-pipe measures such as wastewater treatment plants or filters in environmental protection.

The contrary position is that there is a positive relationship in which business activities advancing environmental and social objectives also increase business success. Typical examples for this positive relationship between voluntary environmental and social activities and business success include lower costs through greater energy and resource efficiency (e.g. Christmann 2000, von Weizsäcker et al. 2009) or customer acquisition through the introduction of natural or organic products (e.g. Burke and Logsdon 1996, Schaltegger and Wagner 2006).

Without going into the reasons for these two contrasting viewpoints (see e.g. Lankoski 2000, Schaltegger and Wagner 2006, Walsh et al. 2003), these examples show that there are activities illustrating both sides and that the relationship between environmental and social engagement (e.g. Griffin and Mahon 1997) and business success will be specific to a given company and will probably be found along a spectrum between these two extreme views. Note that when making a 'business case' for corporate sustainability the sheer number of sustainability activities is less important than how sustainability management is organised (e.g. Schaltegger and Synnestvedt 2002, Schaltegger and Wagner 2006). Depending on the organisation of management, voluntary environmental and social activities will have either a positive or negative effects on business success. This raises the question about the specific approaches needed to develop a business case for corporate sustainability and to support it with the help of a management control system.

4 Drivers for Business Cases of Corporate Sustainability

The evaluation of the effect of environmental and social activities on business success must involve variables that account for the contribution of the company to its own business success (cf., Schaltegger and Wagner 2006:9). The economic effect of sustainability activities can lead to either an improvement or deterioration in the following economic performance drivers (Olve et al. 1999):

- cost and risk;
- turnover, price and profit margin
- innovation
- work satisfaction
- reputation, intangible values and brand value

A first step taken by many companies is to use a checklist to examine sustainability activities in the light of these approaches. With the growing importance of sustainability for business success, there is however a necessity to move beyond checklists to systematically managing elements of sustainability (e.g. Porter and van der Linde 1995a). Management control systems thus face the challenge of explicitly taking elements of sustainability into account (Fischer et al. 2010, Schaltegger and Dyllick 2002). The requirements of identifying the strategic importance of non-market factors and understanding the mechanisms that relate them to business success demands a fundamentally new approach to structuring a sustainability management control approach.

5 Sustainability Management Control Systems at Present Underdeveloped

Conventional management control systems are focused on indicator-based control of financial figures and performance (e.g. Horváth 2009, Weber and Schäffer 2008). The value formal management control aims at creating is to provide a systematic approach for a regular update of business achievements and financial results and enable management to compare this with the defined goals and to act early if differences occur. The job of a controller is to challenge management to reflect the organisational and business development in a rational manner (e.g. Weber and Schäffer 2008).

Unfortunately, conventional management control approaches neglect sustainability issues as long as they are not directly expressed in monetary terms. However, the basic principle of organising a performance management system for continuous improvement promises a systematic approach towards achieving important corporate goals and has been transferred successfully in various areas such as quality management (e.g. Sheldon 1997) and environmental management such as expressed in environmental management systems and standards like ISO 14001, which focus on physical impacts, or eco-control (e.g. Schaltegger and Burritt 2000, Schaltegger and Sturm 1995).

Although the term *sustainability management control* has been sporadically mentioned, a detailed elaboration of the concept does not exist (e.g. Schaltegger 2010). The same can be said, with the exception of Dubielzig (2009), of management socio-accounting and control. As far as eco-control management is concerned, it has been focussed, both in academic publications and in business practice, for about 15 years on manufacturing processes and formal management control systems orientated towards energy and materials flows (cf., for example, Günther 1996, Hallay and Pfriem 1992, Schaltegger and Sturm 1995). Eco-control systems are strongly based and dependent on the development of environmental management accounting (e.g. Schaltegger and Burritt 2000). A more encompassing management control approach towards sustainability management is thus missing, so far.

Sustainability is complex and has a great variety of elements that are relevant to business success (e.g. Lankoski 2006). These can operate in both market and non-market processes. In order to recognise better and successfully manage these elements, however, it is essential that an expanded understanding of management control be developed as well as a broader, but well-structured, concept of sustainability management control.

In this context, equifinality suggests that multiple approaches and organisational forms can be equally effective (Doty et al. 1993, Gresov and Drazin 1997). However, a systematic management approach is needed to structure the processes relating to how to consider various and varying sustainability factors. Since the balanced scorecard (Kaplan and Norton 1992) systematically integrates non-financial factors into management (cf., Kaplan and Norton 1992), it offers great potential for structuring a broader concept of management control that also includes non-market aspects.

6 The Sustainability Balanced Scorecard (SBSC) as a Framework for Structuring Sustainability Management Control

A central task of strategic management control is turning strategic planning into strategic management (Horváth and Partner 2001). The balanced scorecard (BSC) is able to help in the systematic implementation of strategy as well as in the structuring of a variety of management control perspectives (Weber and Schäffer 2000:111). In support of strategic management the BSC helps to take the causal relationships of non-monetary and financial factors into account (Horváth and Partner 2001, Kaplan and Norton 1992).

The sustainability balanced scorecard (SBSC) represents both a strategic management concept as well as a means of measurement, supporting a management logic and performance measurement in the five perspectives of finance, customers, internal business processes, learning and development (cf., Kaplan and Norton 1992, 2001) as well as non-market elements of sustainability (cf., Schaltegger 2004, Schaltegger and Dyllick 2002:38).

6.1 The Fundamental Logic of the SBSC

The SBSC (Figge et al. 2002, Schaltegger 2004, Schaltegger and Dyllick 2002) is a management and structuring method for better integration of the environmental, social and economic aspects of corporate sustainability measurement and management. The SBSC has a multidimensional conception and it is well placed to address the major challenges of corporate sustainability management in an efficient way. The approach addressed conventional management issues and non-market issues of high business relevance. It combines performance measurement in all dimensions of sustainability (Schaltegger and Dyllick 2002, Schaltegger 2004).

In reality environmental and social performance indicators rarely stand alone and separate from each other (see e.g. Schaltegger and Burritt 2000). Therefore, the issue is (1) how to combine them into an overall performance measurement system covering all significant environmental and social performance aspects of a company's operations, (2) to determine what indicators are needed in an overall performance measurement system to measure and manage strategic and operational goals, and (3) how to organise and support the management and information management processes to improve in terms of the indicators.

The starting point of the SBSC is the business strategy which is operationalised through five management perspectives: finance, customer, processes, learning and organisational development and non-market perspective (see Schaltegger and Dyllick 2002) based on cause-and-effect chains linking the strategically relevant aspects in each perspective. The conventional BSC approach (Kaplan and Norton 1992, 2001) in its original form emerges from weaknesses of conventional management accounting (Johnson and Kaplan 1997) and distinguishes a financial perspective, a customer perspective, a business process perspective and a learning and development perspective (Kaplan and Norton 1996, 1997, Olve et al. 1999). The SBSC also integrates non-market issues with a possible fifth perspective – the non-market perspective (Schaltegger and Dyllick 2002). The non-market perspective covers strategically relevant issues which are not covered in market arrangements with the company. Such an example is child labour at a supplier which can have a substantial influence on sales although the company has no market relationship with the children employed by the supplier. The perspectives are linked with cause-and-effect chains.

When developing an SBSC, firstly those environmental and social aspects have to be identified. These matrices serve as checklists to identify the environmental and social exposure of the company. The SBSC process then continues with the identification of strategically relevant environmental and social aspects which potentially have a material impact on the firm's business success. Identification starts out from an analysis of the financial perspective and then progresses through the customer perspective, internal process perspective down to the learning and development perspective and last but not least, the non-market perspective. With this process cause-and-effect chains are developed to reflect linkages between strategically relevant social and environmental aspects and the company's economic success. An important approach used here is the strategy map (Kaplan and Norton 2001) which focuses on the essential links between the business strategy, economic success, performance indicators and operational activities can then be formulated and implemented. The sustainability performance indicators defined on this basis and the implementation of the necessary operational management activities then have to be supported by management control activities.

6.2 A Framework for Structuring Sustainability Management Control

As a management system, the SBSC offers a systematic approach to strategic sustainability management, which leads to a system of key performance indicators. The SBSC is thus an excellent framework for structuring sustainability management control (cf., Fig. 15.2).

There has been little in-depth discussion so far of the conceptual or instrumental relationship of the SBSC to management control and sustainability management control. If the SBSC is taken as a structural framework for the elaboration of a concept

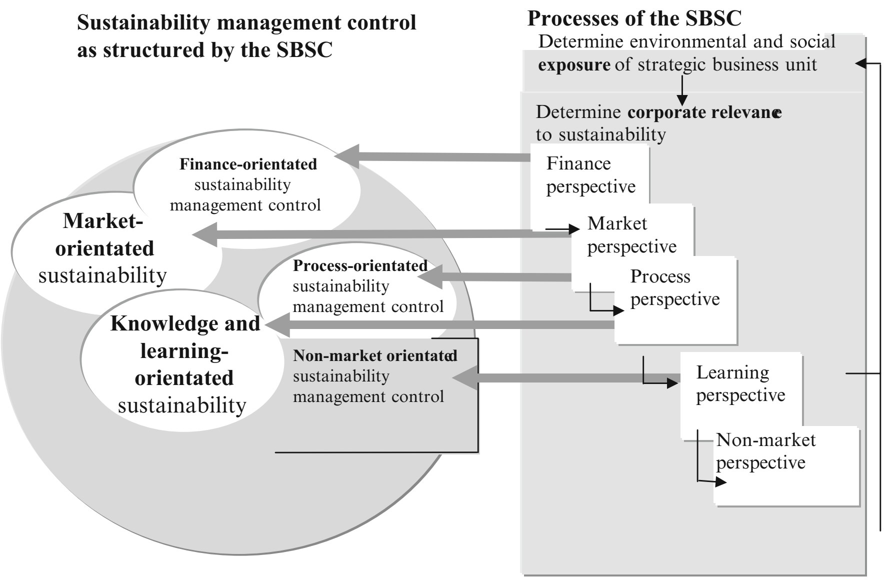

Fig. 15.2 The sustainability balanced scorecard structuring sustainability management control

of sustainability management control, the following orientations, corresponding to the five perspectives of the SBSC, can be distinguished:

- Finance-orientated sustainability management control
- Market-orientated sustainability management control
- Process-orientated sustainability management control
- Knowledge- and learning-orientated sustainability management control
- Non-market–orientated sustainability management control (depicted as a framework within which the four market management control perspectives are located)

As a structuring approach that helps to break down management strategy, the SBSC provides a framework to organise sustainability management control and its orientation towards the effective and efficient implementation of corporate strategy. The starting point is business strategy and the identification of the environmental and social exposure of a given strategic business unit. Following the top-down approach of the BSC, first the environmental and social elements are identified and their relevance is determined and then they are analysed step-by-step for all SBSC perspectives. The result of the analysis is the identification of key performance indicators (KPIs) – strategically-relevant lagging or leading indicators for each perspective – which form the basis for an operative, perspective-orientated sustainability management control system.

Success factors are identified by developing a strategy map (top-down process on the right-hand side in Fig. 15.2) and KPIs are analysed as to their relevance. These make-up the starting point for an operative sustainability management control system orientated to a given sub-system (left-hand side in Fig. 15.2). Such a concept of sustainability management control supports management by providing market and non-market information to help it achieve its sustainability objectives as defined by the relevant KPIs from the SBSC perspectives. Controllers work as advisory sparring partners with management, providing it with information and supporting it with the analysis of the actual situation and the development of proposals for target situations. Sustainability management control has the central task of supporting management so that the success of the company can be strengthened by the special consideration given to environmental and social issues. This entails that the relevance of elements of sustainability regarding the drivers of business cases are identified and analysed, effective measures are developed and evaluated and the implementation is carried out in a way that strengthens the company's success. Furthermore, the approach addresses the concept of equifinality of control (e.g. Jennings and Seaman 1994) that particular control outcomes and the overall goal of corporate sustainability are achievable from different starting points and via different paths.

Sustainability management control thus has as its goal the continuous improvement of environmental and social performance, in an iterative process with management, while at the same time furthering the company's business success. This goal is achieved by means of information, decision-making, planning, communication and control systems that provide management with decision-making support.

6.3 *Perspectives of Sustainability Management Control*

6.3.1 Finance-Orientated Sustainability Management Control

Sustainability management control based on SBSC key performance indicators is also aligned with current concepts in finance management and unites environmental and social elements with accounting. The task of finance-orientated sustainability management control may be mainly in the provision of information as well as management and adaptation of accounting concepts (cf., e.g. Schaltegger and Burritt 2009, Schaltegger et al. 2008). While there are already concepts and in some instances extensive practical experience with individual topics such as shareholder value-orientated environmental management (so-called environmental shareholder value), materials flow accounting or the influence of contaminated sites on (potential) liabilities and sustainability accounting, there is still a need for work in other areas (e.g. social elements and shareholder value, sustainability and economic value added) of finance-orientated sustainability management control.

6.3.2 Market-Orientated Sustainability Management Control

Effective management of company activities cannot be ensured without sufficient attention to market success. Thus especially ecologically orientated changes in production processes or changes in product design can have a considerable (potentially positive or negative) influence on sales and market acceptance which means that a rethinking of communication and marketing is necessary.

The development of market-orientated sustainability management control can begin with internal company customers asking for management control services and with the clarification of what new management control services could be important for existing and new customers. Contact persons can be found in production, human resources, as well as the sustainability officer. These people should be involved in discussions of the KPIs at regular intervals and writing the public sustainability report.

The objective of market-orientated sustainability management control is to create a specific relationship between a company's sustainability activities and its marketing success. This requires good cooperation with the marketing department and includes dealing with questions ranging from product development to marketing communication and distribution. It can also include issues of optimising products and supply chain costing and management control (cf., e.g. Seuring 2001). This means that the performance indicators are extended beyond the boundaries of the company, while being clearly targeted at ecological and social improvements in the market-relevant overall performance. There is thus a close relationship to process-orientated sustainability management control.

6.3.3 Process-Orientated Sustainability Management Control

The focus of environmental management accounting and eco-control on production processes has tradition (cf., for example, Günther 1996, Hallay and Pfriem 1992, Schaltegger and Sturm 1995, also for published case studies). In the foreground are financial indicators in production as well as the relationship between non-financial indicators in production and financial results (see e.g. Jasch 2009, Schaltegger et al. 2008). A process-orientated sustainability management control however goes beyond a concentration on environmental problems with technical production processes. Alongside production processes other business processes such as innovation, management, logistics or customer service are a part of the process perspective of the SBSC. Many management fads, such as lean management, systems re-engineering, or total quality management, essentially involve a process orientation. Some of these approaches can at least to an extent be found in environmental and quality management (e.g. total quality environmental management).

The most important steps of process-orientated sustainability management control include the analysis and optimisation of processes. Distinctions can be made here between core processes and core process chains, the definition of customer, social and environmental requirements, the implementation in causal relationships and measurable indicators as well as internal reporting.

Process optimisation demands motivated and competent employees; since effective and efficient sustainability management may necessitate profound and continuous change sustainability management control must consider ecological learning processes and motivation.

6.3.4 Knowledge and Learning-Orientated Sustainability Management Control

With the growth of information technology, consulting services and the rising share of services even in material-intensive industries such as the automobile and machine tool industries, the importance of know-how, information and employee motivation is increasing. Knowledge management includes the use of information technology solutions in environmental and social management, e.g. environmental databases and software, and the provision of training seminars. It is much more important to enable employees to create, identify and successfully implement innovations. Sustainability management control is challenged to provide support in the chain from data retrieval to the successful implementation of know-how. The structuring and networking of information to business-relevant knowledge about sustainability as well as the support of a learning and innovation-friendly corporate culture serve an efficient exchange of knowledge between employees and external experts.

These relationships are soft and hard to quantify and there is a danger of undertaking actions under the name of knowledge management that have little effect.

It is thus crucial to focus on those areas that a prior SBSC analysis has shown are being relevant to business success. This can include non-market processes in the social, legal and political environment of the company.

6.3.5 Controlling Non-market Elements of Sustainability

The market is shaped by market parameters and is a social, political and legal construct. Since they can change the rules governing the market, in certain cases non-market factors can have a more fundamental character than market variables. The non-market environment can be divided into socio-cultural, legal and political factors.

Socio-cultural issues involve the social acceptance or legitimation of business activities and the provision of business products and services, traditions, social values, media reactions and public opinion. An important part of issue management involves the relationship to opinion leaders, trendsetters and other key organisations and individuals.

Management control of non-market factors also takes into account those legal developments relevant to the company. An interface between the socio-cultural and legal environment is provided by voluntary standards of environmental and sustainability management, such as for example EMAS, ISO 14000, ISO 26000. A central challenge for small and medium-sized enterprises is attaining an overview of the innumerable social and environmental laws as well as ensuring legal compliance with such legislation. Multinational corporations are confronted with a great variety of national legal systems. The dynamic development of legal conditions and the increasing importance of European Union regulations create special difficulties. Management control orientated towards legal compliance will rarely have a strategic position in a company. Its importance is more in the management of hygiene factors. Its task is in providing cost-effective legal compliance through systematic analysis and the anticipation of changes in the legal environment.

Interest-group processes often have a very direct influence on the ability of management to take action (e.g. Freeman 1984), yet they are rarely analysed explicitly. Interest-group activities are, however, the most effective way of pursuing goals for a number of stakeholders, especially NGOs (e.g. Frooman 1999). Consumer boycotts, neighbourhood protests, actions to influence politicians, or media attention are examples of the different ways interest-groups express themselves. Mostly the legitimacy of certain corporate actions or products is questioned. However, interest-group activities are not limited to negative action. An increasingly used and powerful approach of interest-groups is to express themselves in social media in the Internet. Here various Internet communities have developed with the aim of supporting ‘strategic consumption’, i.e. the consumption of fair-trade and organic products or responsible companies.

In spite of the great importance of interest-group processes in many industries, the approach in this area of management is often intuitive. There is not yet a sustainability management control system orientated towards interest groups, even though over the past 10 years basic management concepts have been developed.

If non-market elements are seen to be strategically-relevant when developing the SBSC – taking the form of performance drivers such as corporate reputation or social trends – then it is important to manage them explicitly using non-market-orientated sustainability management control. However, even when non-market environmental and social factors are seen to be 'only' hygiene factors for a company, sustainability management control can still help to manage legal compliance issues in an efficient way. The task of management control of non-market elements of sustainability then takes on the character of information provision. In situations of great strategic relevance, by contrast, the role of management consulting plays a crucial role.

7 Outlook

The SBSC is a management and measurement concept that systematically accounts for elements of sustainability according to their relevance for business success in strategic management. The analysis of causal chains and the development of a strategy card create the conditions for an indicator-supported strategic measurement and management system.

A sustainability management control system based on the SBSC concept has five different variations: finance-orientated, market-orientated, process-orientated, knowledge- and learning-orientated and non-market-orientated sustainability management control. Figure 15.3 shows possible generic indicators and performance drivers for sustainability management control based on the five perspectives of the SBSC. The decisive criteria for the development of services and performance indicators for sustainability management control must be its contribution to business success.

Type	**Possible indicators**	**Possible performance drivers**
Finance-orientated	Shareholder value, RONA	Minimising contaminated sites, low emission costs
Market-orientated	Market value, turnover	Market acceptance, higher prices for sustainable products
Process-orientated	Innovations, process efficiency	Sustainability risks in supply chains, material flow costs
Learning and development-orientated	Innovation potential	Database services and use of sustainability information
Non-market orientated	Reputation, legal compliance	Media response, awards

Fig. 15.3 Possible generic indicators and performance drivers of sustainability management control based on the five SBSC perspectives

These five perspectives of sustainability management control yield the following 'internal customers' as potential partners:

- Sustainability management department and strategic planning department as an integrated component of sustainability management control
- Accounting and management control department for finance-orientated sustainability management control
- Market research and marketing department for market-orientated sustainability management control
- Production management and research and development department for process-orientated sustainability management control
- Human resources department of the company for knowledge and learning-orientated sustainability management control
- Public relations office and the strategic management unit for non-market sustainability management control

This role as an interface allows sustainability management control as a process to take on a coordination and integration function that does justice to the interdisciplinary character of sustainability management. However, there is still the challenge of making a real contribution to the various functional areas of a company. This complex challenge should not, however, act as a deterrent because the sustainability management controller takes on a role of moderation and consulting that would be necessary in any case. The danger of dilettantism in many functional areas only exists when the internal customer orientation of sustainability management control process is confused with that of an internal police officer pursuing environmental and social wrongdoings, a task that at any rate would be doomed to failure.

The concept of an SBSC-based sustainability management control system outlined here needs to be further developed, as even progressive companies manage individual functional areas in a fragmented fashion. If the logic of the SBSC, which serves to break down and implement corporate strategy and support the elements of sustainability relevant to business success, is followed then it becomes apparent that, if elements of sustainability relevant to business success are to be systematically accounted for, management control should be more closely involved.

References

Bhimani A and Soonwalla K (2005) From conformance to performance: the corporate responsibilities continuum *Journal of Accounting and Public Policy* 24.3 165–174

Burke L and Logsdon J M (1996) How corporate social responsibility pays off *Long Range Planning* 29.4 495–502

Christmann P (2000) Effects of 'best practices' of environmental management on cost advantage: the role of complementary assets *Academy of Management Journal* 43.4 663–680

Doty D, Glick W and Huber G (1993) Fit, equifinality, and organizational effectiveness: a test of two configurational theories *Academy of Management Journal* 36.6 1196–1250

Dubielzig F (2009) *Sozio-Controlling in Unternehmen: Das Management erfolgsrelevanter sozial-gesellschaftlicher Themen in der Praxis (Social Management Control: The Management of Social Topics in Corporate Practice)* Wiesbaden, Gabler

Esty D and Porter M (1998) Industrial ecology and competitiveness: strategic implications for the firm *Journal of Industrial Ecology* 2.1 35–43

Figge F, Hahn T, Wagner M and Schaltegger S (2002) The sustainability balanced scorecard. Linking sustainability management to business strategy *Business Strategy and the Environment* 11.5 269–284

Fischer T, Huber R and Sawczyn A (2010) Nachhaltige Unternehmensführung als Herausforderung für das Controlling (Sustainable management of companies as challenge for management control) *Controlling-Zeitschrift für erfolgsorientierte Unternehmenssteuerung* 22.4/5 222–230

Freeman E (1984) *Strategic Management: A Stakeholder Approach* Marshfield, Pitman Publ.

Frooman J (1999) Stakeholder influence strategies *Academy of Management Review* 24.2 191–205

Gresov C and Drazin R (1997) Equifinality: functional equivalence in organization design *Academy of Management Review* 22.2 403–428

Griffin J and Mahon J (1997) The corporate social performance and corporate financial performance debate: twenty five years of incomparable research *Business & Society* 36.1 5–31

Günther E (1996) *Ökologieorientiertes Controlling. Konzeption eines Systems zur ökologieorientierten Steuerung und empirischen Validierung (Ecologically Oriented Management Control. Concept of a System to Pilot and Empirical Validation)* München, Vahlen

Hallay H and Pfriem R (1992) *Öko-Controlling: Umweltschutz in mittelständischen Unternehmen (Eco-control: Environmental Protection in SMEs)* Frankfurt, Campus

Hemphill TA (1997) Legislating corporate social responsibility *Business Horizons* 40.2 53–58

Holme R and Watts O (2000) *Corporate Social Responsibility: Making Good Business Sense* Geneva, WBSCD

Horváth P (2009) *Controlling (Management Control)* (11th edition) Munich, Vahlen

Horváth P and Partner (editors) (2001) *Balanced Scorecard umsetzen (Implementing the Balanced Scorecard)* Stuttgart, Schaeffer-Poeschel

Jasch C (2009) *Environmental and Material Flow Cost Accounting* Dordrecht, Springer

Jennings D and Seaman S (1994) High and Low Levels of Organizational Adaptation: An Empirical Analysis of Strategy, Structure, and Performance *Strategic Management Journal* 15.6 459–475

Johnson H and Kaplan R (1997) *Relevance Lost: The Rise and Fall of Management Accounting* Boston, Harvard Business Press

Kaplan R and Norton D (1992) The balanced scorecard – measures that drive performance *Harvard Business Review* 70.1 71–79

Kaplan RS and Norton DP (1996) *The Balanced Scorecard: Translating Strategy into Action* Boston, Harvard Business School Press

Kaplan RS and Norton DP (1997) Why does business need a balanced scorecard? *Journal of Cost Management* (May/June): 5–10

Kaplan R and Norton D (2000) Having trouble with your strategy? Then map it *Harvard Business Review* 78.5 167–176

Kaplan R and Norton D (2001) *The Strategy-focused Organization: How Balanced Scorecard Companies Thrive in the New Business Environment* Boston, Harvard Business Press

Lankoski L (2000) *Determinants of Environmental Profit* Helsinki, Helsinki University of Technology

Lankoski L (2006) Environmental and economic performance: the basic links *in* Schaltegger S and Wagner M *Managing the Business Case of Sustainability. Sustainability Performance, Competitiveness and Business Success* Sheffield, Greenleaf 32–46

Massey J (2001) Managing organizational legitimacy: communication strategies for organizations *Journal of Business Communication* 38.2 153–183

Olve N, Roy J and Wetter M (1999) *Performance Drivers* Chichester, Wiley

Porter ME and van der Linde C (1995a) Toward a new conception of the environment-competitiveness relationship *Journal of Economic Perspectives* 9.4 97–118

Porter ME and van der Linde C (1995b) Green and competitive: ending the stalemate *Harvard Business Review* 73.5 120–133

Schaltegger S (2004) Sustainability balanced scorecard: Unternehmerische Steuerung von Nachhaltigkeitsaspekten (The Sustainability balanced scorecard: piloting sustainability issues of companies) *Controlling* 8.9 511–516

Schaltegger S (2010) Nachhaltigkeitscontrolling (Sustainability control) *Controlling* 4 511–516

Schaltegger S, Bennett M, Burritt RL and Jasch C (editors) (2008) *Environmental Accounting for Cleaner Production* Dordrecht, Springer

Schaltegger S and Burritt R (2000) *Contemporary Environmental Accounting* Sheffield, Greenleaf

Schaltegger S and Burritt RL (2010) Sustainability accounting for companies: catchphrase or decision support for business leaders? *Journal of World Business* 45.4 375–384. DOI: 10.1016/j.jwb.2009.08.002

Schaltegger S, Burritt R and Petersen H (2003) *An Introduction to Corporate Environmental Management: Striving for Sustainability* Sheffield, Greenleaf

Schaltegger S and Dyllick T (editors) (2002) *Nachhaltig managen mit der Balanced Scorecard (To Manage Sustainably with the Balanced Scorecard)* Wiesbaden, Gabler

Schaltegger S and Sturm A (1995) *Eco-efficiency Through Eco-control* Zürich, VDF

Schaltegger S and Synnestvedt T (2002) The link between "green" and economic success: environmental management as the crucial trigger between environmental and economic performance *Journal of Environmental Management* 65.4 339–346

Schaltegger S and Wagner M (2006) *Managing the Business Case of Sustainability. Sustainability Performance, Competitiveness and Business Success* Sheffield, Greenleaf

Sheldon C (editor) (1997) *ISO 14001 and Beyond: Environmental Management Systems in the Real World* Sheffield, Greenleaf

Seuring S (2001) *Supply Chain Costing* München, Vahlen

Walsh J, Weber K and Margolis J (2003) Social issues and management: our lost cause found *Journal of Management* 29.6 859–881

Weber J and Schäffer U (2000) *Balanced Scorecard & Controlling: Implementierung, Nutzen für Manager und Controller: Erfahrungen in deutschen Unternehmen (Balanced Scorecard and Management Control: Implementation, Benefit for Managers and Controllers)* Wiesbaden, Schaeffer-Poeschel

Weber J and Schäffer U (2008) *Einführung in das Controlling (Introduction to Management Control)* Stuttgart, Schaeffer-Poeschel

von Weizsäcker EU, Hargroves K, Smith M, Desha C and Stasinopoulos P (2009) *Factor Five: Transforming the Global Economy Through 80% Improvements in Resource Productivity* London, Earthscan

Chapter 16
Impact Assessment in the European Union: The Example of the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

Anna Széchy

Abstract The role of impact assessments in European Union decision-making has increased greatly over the past few years as a part of efforts to boost the Community's economic performance through improvement of the regulatory environment. In the field of environmental legislation, however, such quantification and monetization efforts involve a number of theoretical and practical problems which could undermine the possibility of obtaining an unbiased outcome. This chapter examines the European Union's environmental impact assessment practices using the example of the *Registration, Evaluation, Authorisation and Restriction of Chemicals* (REACH), the European Union's new chemicals policy. As a highly significant piece of legislation the likely effects of REACH were subjected to thorough analysis by the European Commission as well as key stakeholders. It is shown that, while underpinning the expected positive overall outcome of the regulation, uncertainty involved in estimating the benefits results in limited applicability of the impact assessment's findings in the decision-making process and contributes to the fact that REACH was finally adopted with substantially lower requirements than originally planned.

Keywords REACH • Impact assessments • European Union • Chemicals • Environmental legislation

1 Introduction

Improving the quality of decision-making is receiving greater attention in the European Union (EU) as it strives to increase its international competitiveness as well as to improve its fading popularity among its own citizens. Impact assessments

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including quantified estimates of the proposed legislation's costs and benefits play an important role in these efforts. The quality and meaningfulness of such assessments have generated much criticism in recent years (see for example Franz and Kirkpatrick 2007, Pallemaerts et al. 2006, Renda 2006, The Evaluation Partnership 2007).

In the field of environmental decision-making impact assessments are especially hard to perform because of the difficulties associated with the quantification of environmental effects. This chapter examines the impact assessment process of what is probably the most significant piece of EU environmental legislation in recent years: the new chemicals policy known as REACH, an acronym of the *Registration, Evaluation and Authorisation of Chemicals*.

A total of 42 impact studies by various stakeholders are included, either directly or indirectly, in the research with special emphasis on the documents prepared by or upon request of the European Commission (EC) (see Table 16.1). The REACH

Table 16.1 Overview of impact assessments included in the study

Study	Description
European Commission Extended Impact Assessment (European Commission 2003b)	Official impact assessment of the European Commission including the economic, health and environmental effects of REACH. (Contains monetized estimates for costs and a rough estimate for health benefits).
ECORYS and OpdenKamp Adviesgroep for the Dutch presidency of the EU: The impact of REACH – Overview of 36 studies (Witmond et al. 2004)	A detailed overview of 36 studies by various stakeholders prepared up to October 2004.
DHI Water & Environment for the European Commission: The impacts of REACH on the environment and human health (Pedersen et al. 2005)	Provides monetized examples for environment and health benefits of REACH using various methodologies.
KPMG for UNICE/CEFIC (under a memorandum of understanding with the European Commission): REACH – further work on impact assessment. A case study approach (Bolt et al. 2005)	Aims to clarify potential business impacts (focusing on substance withdrawal and innovation) using a case study approach examining four downstream sectors.
European Commission Joint Research Centre, Institute for Prospective Technological Studies (under a memorandum of understanding with industry): Implementation of REACH in the New European Member States (EC JRC 2005)	Aims to clarify the potential economic impact of REACH for the New Member States, analysing the chemicals sector in these countries and the specialty chemicals industry in particular.
Ökopol for the European Commission: Analysis of studies discussing the benefits of REACH (Reihlen and Lüskow 2007)	A detailed overview of 13 studies discussing the potential benefits of REACH.

case study is a valuable example providing insight into the role and effect of quantitative impact assessments in EU environmental policy formulation.

This chapter proceeds as follows. Section 2 looks at the impact assessment practices of the EU in general, including the evolution of the current system and its performance so far, as well as an overview of the problems associated with the treatment of environmental effects in quantitative analyses. Section 3 examines the impact assessment process of REACH with a detailed description of the expected costs and benefits and their estimation. The conclusions can be found in Sect. 4, while Sect. 5 contains recommendations.

2 Impact Assessment in the EU

2.1 Evolution of Current Practice

The practice of regulatory impact assessment in the EU goes back to 1986 when the *Business Impact Assessment* procedure was introduced to examine the compliance costs of certain regulations for EU enterprises. The limited scope, lack of scientific soundness and, usually, ex post nature of these assessments meant that they were of little use in the decision-making process – a situation that additional tools introduced during the 1990s did not improve (Renda 2006).

Efforts to enhance the quality and usefulness of impact assessments gained momentum with the formulation of the *Lisbon Agenda*, "better" regulation being regarded as having a central role in reaching the ultimate goal of increased competitiveness (Mandelkern Group 2001). The better regulation initiative aims to simplify and improve the regulatory environment by ensuring that EC action only takes place when this brings clear added value and that the best policy option is chosen. In order to achieve this, the EC's impact assessment practices underwent complete reform and a new system of Integrated Impact Assessments (IIAs) was introduced, from 1 January 2003 (European Commission 2002). The term *integrated* means that these assessments are no longer limited to the business impacts of proposals but also include the social and environmental dimension in line with the EU's Sustainable Development Strategy adopted at the Göteborg Council in 2001 (European Commission 2001b).

IIAs are ex ante in nature the goal being to identify and compare all possible policy options – including that of no action. Wherever possible the analysis should include quantitative and monetized estimates of the likely effects. Stakeholder consultation is also a requirement. The duty to perform impact assessments has been extended to all proposals in the EC's *Legislative Work Programme* with the depth and scope of the analysis depending on the importance of the proposal and the magnitude of its likely effects – the principle of proportionality.

The importance of better regulation via impact assessments has been reinforced in connection with revision of the *Lisbon Strategy* in 2005 (European Commission 2005a). At the same time, the new focus on growth and jobs, a reaction to the EU's disappointing economic performance, tends to put environmental and social goals at a disadvantage next to the competitiveness agenda (Pallemaerts et al. 2006). This shifting of priorities can be clearly felt in the Commission's statement on the refocused Lisbon strategy: "meeting Europe's growth and jobs challenge is the key to unlocking the resources needed to meet our wider economic, social and environmental ambitions" (European Commission 2005a:7); and in the statement on better regulation, which stresses the need to deepen the economic element of IIAs (European Commission 2005b).

2.2 The Environment in Impact Assessments

Where the environment is concerned the use of impact assessments and monetized cost-benefit analyses has always been controversial. Monetization can help draw decision-makers' attention to effects that would otherwise tend to be overlooked or downplayed. This is the reason why such techniques are widely embraced by advocates of the environmental cause and considerable scientific attention devoted to their improvement. However, this positive picture is increasingly being challenged by ecological economists who call attention to a number of theoretical and practical considerations which question the monetary valuation of environmental goods. The main argument is the high degree of complexity in the natural environment which makes it impossible to isolate and separately value environmental goods (O'Neill and Spash 2000, Vatn and Bromley 1994). Connected to this is our limited knowledge regarding the functioning of ecosystems, meaning we can never be certain about the effects of human-induced changes which often defy the assumptions of conventional economic analysis involving irreversible changes and threshold effects (Gowdy and Erickson 2005, Vatn and Bromley 1994).

Moral arguments are also very important such as those about inter- and intragenerational equity – valuation techniques attach smaller values to environmental effects if they concern future generations or poor populations (Martinez-Alier 1995). Researchers are often confronted with the problem of respondents not willing to name monetary figures and accept trade-offs in case of environmental goods (Gowdy and Erickson 2005, O'Neill and Spash 2000). Ecological economists raise the concern that evaluation attempts may not actually be a process of measuring existing preferences; rather they are responsible for creating them (O'Neill and Spash 2000). That is to say, people may not originally be inclined to consider the environment in monetary terms but valuation exercises eventually teach them to accept this way of thinking.

2.3 Lessons from Implementation

Next to the underlying theoretical doubts the practice of performing impact assessments in the EU is also under constant scrutiny. Several studies have been published aiming to evaluate experiences since the introduction of the IIA system. These find a series of shortcomings indicating that IIAs are still far from providing a universal tool for achieving effective and efficient regulation.

Examining the 70 extended impact assessments undertaken by the EC between 2003 and 2005, Renda (2006) finds that most of them do not actually contain monetized estimates of the proposal's costs and benefits: in 40% of the cases some of the costs were monetized and in 27.1% all costs; for benefits the rates are even lower – in 28.6% of the assessments some of them being monetized and in only 14.3% all of them. Further problems include a lack of comparison of possible regulatory alternatives, methodological concerns, as well as poor presentation of the assessments' findings.

The evaluation report prepared for the EC by independent consultants in 2007 (The Evaluation Partnership 2007) emphasises the variability of the impact assessments' quality: assessments of legislative proposals or action plans generally being more satisfactory than those of other non-legislative proposals or spending programmes. Among the problems identified are a lack of the necessary expertise, time and resources to carry out high quality assessments, as well as a tendency to see IIAs as merely a bureaucratic exercise to justify a policy choice that has already been made. Both factors lead to limited trust and therefore limited reliance on the assessments' findings in the decision-making process.

In relation to environmental impacts, analysts note that these generally receive less attention in impact assessments than economic effects and suggest that this bias naturally results from favouring quantitative and monetized estimates and is therefore inherent in the impact assessment system (Franz and Kirkpatrick 2007, The Evaluation Partnership 2007). In the United States, where cost-benefit analysis is extensively used in policy-making, impact assessment is also intensively criticised by some researchers as a non-neutral, anti-regulatory instrument (Ackerman et al. 2004, Driesen 2005).

3 Assessing the Impacts of REACH

The EU's new chemicals policy, known as REACH, is widely regarded as one of the most complex pieces of legislation ever adopted (European Parliament 2006, Rennie 2005). REACH is expected to have substantial effects for industry as well as human health and the environment providing an ideal example to examine the EU's impact assessment practices for environmental legislation.

3.1 Background

REACH was born from the realisation that the amount of information available on the health and environment effects of chemical substances on the EU market was too limited to ensure safe use. Earlier regulations required all chemicals placed on the market from 1981 to undergo thorough testing but previously existing chemicals were not subjected to this requirement. This created an incentive for the chemical industry to avoid testing costs by continuing to use existing substances resulting in a situation where as few as 3,800 new substances shared the market with around 100,000 older, and thus untested, ones.

The new regime extends the testing requirements to existing substances depending on their volume range. The responsibility now lies with the producers and importers of chemicals to demonstrate that their substances have no adverse effects and to pass on all information necessary for safe use along the supply chain. The most hazardous substances will possibly be banned from further use.

By enhancing chemical safety REACH is expected to provide substantial benefits: reducing chemical-related illnesses and environmental damage as well as restoring consumer confidence in the industry and promoting innovation by putting an end to the differential treatment of new substances. However, the costs of testing, as well as the costs of the substitution of hazardous chemicals, place a significant burden on industry.

The chemicals sector is one of the EU's most successful industries recording a substantial trade surplus and providing about 1.3% of Community gross domestic product (GDP) as well as about 1.2 million jobs (European Commission 2003b). However, this global leadership position is under increasing pressure from the United States and Asian competitors. Because of the widespread use of chemicals throughout the entire manufacturing sector any impact on the chemical industry may have far reaching effects across the entire spectrum of European industry (European Commission 2003b).

3.2 Assessing the Impacts of REACH

The REACH regulation became subject to one of the most profound impact assessments undertaken after the introduction of the IIA system. Although the preparations for a reform of the EU's chemicals policy had already begun in 1998, 2003a it was not until 2003 that the EC issued a formal regulatory proposal (European Commission) accompanied by an extended impact assessment (European Commission 2003b) according to the new regime. In preparation for the proposal, an extensive public consultation procedure was conducted including an Internet-based survey with around 6,000 responses from various stakeholders such as industry, non-government organisations (NGOs), member states and individuals.

The inter-institutional decision-making process took another 3 years to complete finally resulting in the adoption of REACH in late 2006, which entered into force in June 2007 (European Commission 2006). During this time further work on impact assessment was undertaken by various research institutes upon request of the EC as well as other stakeholders notably from the chemical industry. In reaction to the concerns regarding the competitiveness of the European chemical companies, most of the changes that REACH underwent before its adoption brought a reduction in its requirements.

Table 16.1 provides an overview of the impact assessments included in this study all of which are based on the EC's legislative proposal of 2003. The assessments examined in detail are those prepared by/upon request of the EC itself[1], as these are assumed to have had the highest influence on the policy process, while a wide range of other contributions, mainly from environmental NGOs, member states and industry organisations, are included based on their summaries provided in the works of Witmond et al. (2004) and Reihlen and Lüskow (2007).

The studies show great variability in depth with some studies providing monetized estimates of costs and/or benefits, others only describing the likely effects, scope, from comprehensive studies and to others only examining individual member states, sectors or certain types of impacts, as well as methodology through economic modelling, case studies, etc. Contributions from industry and environmental NGOs are often not actual impact assessments but position papers used in the policy discussion containing claims on the expected impacts of REACH (see for example Cefic 2004, ChemSec 2004 and other examples in Witmond et al. 2004).

3.3 Costs

The costs of REACH can be grouped into direct and indirect categories: the former referring to the expenses of chemical companies in order to ensure compliance with the regulation and the latter meaning all other economic losses resulting from REACH across the entire EU economy.

The direct element consists mainly of the costs of performing tests required for the registration of substances, and also includes administrative costs and fees to be paid to the European Chemicals Agency, a new institution with the responsibility of managing REACH processes. These are relatively easy to estimate, since the costs of carrying out certain substance tests are known – there is some uncertainty as to how much REACH-compatible information is already in the possession of chemical companies.

The EC's impact assessment puts the direct costs of REACH at a total of €2.3 billion, spread over the 11-year period of the registration process. This, like other figures in the impact assessment, is an estimate only for the EU15 – for the 10 countries who joined the EU in 2004, the EC expects effects proportionate to the size of their chemicals sector which is much smaller – only about 4% of the industry in the EU15 (European Commission 2003b). However, as the financial and market position of chemical companies is generally weaker in the new member states, they may find it harder to cope (EC JRC 2005).

[1]An overview of these studies (as well as other useful information on REACH) can be found on the European Commission's website at http://ec.europa.eu/environment/chemicals/reach/background/i_a_en.htm

While direct costs may seem high at first glance, it should be noted that the amount indicated for REACH equals only about 0.05% of the chemical industry's annual turnover (European Commission 2003b). But as representatives of the chemical industry point out, the distribution of these costs within the sector will be uneven with a large part of the burden falling on the producers of specialty chemicals – mainly small- and medium-sized enterprises characterised by the high number and low volume of their substances. The European Chemical Industry Council estimates that 20% of chemical companies will be bearing 80% of the registration costs (Cefic 2004).

The original ideas for REACH as set out in a *White Paper* published by the EC in 2001 (European Commission 2001a) envisions far more extensive testing requirements but, as a result of the following public consultation procedure, many tests were dropped especially in the lower volume ranges resulting in an 80% decrease of the expected registration costs (European Commission 2003b). Further impact assessment carried out by KPMG under a memorandum of understanding between the EC and industry in 2004 indicates that lower volume chemicals and small- and medium-sized enterprises are still relatively vulnerable (Bolt et al. 2005). These findings influenced decision-makers to adopt a final text which further reduces the testing requirements for substances under 100 tons per year (EU 2005).

Two factors that may strongly influence the direct costs and also the need for animal testing are the extent of application of (Quantitative) Structure–Activity Relationships [(Q)SARs] and One Substance One Registration principle. (Q)SARs are methods that allow determination of the properties of a substance based on its molecular structure and similarities to other substances. These are currently being developed and validated and the testing costs of REACH greatly depend on how soon and how widely they can be used. OSOR refers to the sharing of information between the registrants of identical substances to avoid unnecessary testing – in principle this sharing is mandatory but exceptions can be granted to protect sensitive business information and could, in practice, provide a loophole for large companies who would rather leave financially weaker competitors to struggle on their own. The EC's €2.3 billion estimate for the direct costs of REACH assumes the availability of (Q)SARs before the registration of lower volume substances begins, as well as a high level of information sharing (European Commission 2003b). Other studies have generally arrived at slightly higher cost figures, up to €4 billion (Witmond et al. 2004).

The indirect costs of REACH mainly affect the downstream users of chemicals and largely depend on how many chemicals will be withdrawn from the market and how difficult their substitution will be. Withdrawal can occur either because a hazardous substance is not granted authorisation or, more often, because the producer of a substance decides not to incur the costs of registration. This effect is naturally much more difficult to predict leading to a much higher variance in the estimates for the expected indirect costs.

The EC, using a micro-economic model to forecast company behaviour under changing market circumstances (e.g. increased costs because of REACH), comes to the conclusion that only 1–2% of substances will be withdrawn, resulting in indirect costs in the range of €2.8–3.6 billion, and no significant macroeconomic effects such as loss of jobs or GDP (European Commission 2003b). By contrast, many industry studies, largely using case study approaches based on surveys among chemical companies, speak of devastating results with substance withdrawals of up to 30% resulting in hundreds of billions of Euros and millions of jobs lost throughout the EU (Witmond et al. 2004).

The EC points out that the costs to downstream users are unlikely to exceed the magnitude of the direct costs since the downstream users can prevent the withdrawal of substances that are critical to them by helping to cover the costs of registration (European Commission 2003b). Therefore, industry studies assuming the loss of large numbers of substances are considered unrealistic. Many have also criticised the case study approach as this often leads to strategic answers from company representatives (Witmond et al. 2004). Environmental NGOs remind of previous experience with environmental legislation where in general the actual costs are substantially lower than industry forecasts (ChemSec 2004).

3.4 Benefits

REACH is expected to deliver many benefits mainly in the field of human health and the environment. It will reduce the damages caused by harmful chemicals through improved risk management and the substitution of hazardous substances with safer ones. While all studies agree that the benefits of REACH will be substantial, they could not be estimated in a similar way to the costs. Attempts to quantify the benefits only go so far as to provide some examples which could give an impression of their likely scale. However, even these partial estimates require difficult assumptions.

The main problem for the benefit calculations lies in the fact that very little is known about the initial situation that REACH is expected to improve. It is the main goal of REACH to alleviate the lack of information about the harmful properties of chemical substances. Without this information it is not possible to tell what damage is caused by such substances today. Thus, there is no baseline against which the expected results of REACH can be compared (European Commission 2003b, Reihlen and Lüskow 2007).

In its impact assessment (European Commission 2003b) the EC gives an estimate for the health benefits of REACH stressing that it is only a partial example and should not be interpreted as an official figure for the expected benefits. Assuming that chemical-related illnesses, mainly cancer but also skin and respiratory diseases, are about 1% of the total disease burden in the EU and that REACH will reduce these by 10%, they arrive at a saving of €50 billion over 30 years – assuming a statistical value of €1 million per human life and a 3% discount rate. To compensate for the uncertainties regarding the elements of the calculation, prudent estimates are used throughout.

As for the environmental effects of the new policy, knowledge is even more limited. However, it is shown that many animal populations suffer from exposure to chemicals, e.g. thinning of egg shells (European Commission 2003b). Furthermore, it is also clear that much of the damage to human health also occurs via the environment. The EC itself mentions the benefits that will probably result from reducing the environmental presence of harmful chemicals but does not attempt to quantify them (European Commission 2003b). *DG Environment* has, however, commissioned a study (Pedersen et al. 2005) that aims to gain an impression of the possible magnitude of benefits by concentrating on a few of the more tangible environmental effects and using several methods to monetise them.

The approach considered most reliable calculates the current costs of mitigating chemical pollution (e.g. drinking water purification, treatment of contaminated sewage sludge) and assumes that REACH would reduce these by 10% – resulting in a saving of €2.8–9 billion over 25 years. The willingness to pay method results in substantially higher figures, while the least robust approach based on past damages from substances whose harmful effects are now well known, provides estimates up to €52 billion. It should be noted that all of the above estimates relate only to the chosen examples and not to the entirety of possible environmental benefits (Pedersen et al. 2005).

Alongside the improvements to human health and the environment, REACH is thought to be associated with a wide range of business benefits which are, however, intangible in nature and do not receive as much attention in the impact assessments as the other effects. Such benefits may include increased consumer confidence in the chemical industry, improved communication in the supply chain, a reduction of future liability payments and increased innovation (European Commission 2003b, Reihlen and Lüskow 2007, Witmond et al. 2004).

The issue of innovation was rather controversial in the discussion of impacts with industry representatives fearing a negative effect because of REACH compliance diverting the financial and human resources from research and development (R&D). While some concerns regarding human capacities could be justified, the EC considers that with testing costs only amounting to 3% of the industry's annual R&D budget REACH should have a positive effect on innovation, especially in the longer term (European Commission 2003b, Witmond et al. 2004). This is because of the level playing field it creates between existing and new substances, with the requirements for new substances made even easier, with registration only required above one tonne per year, as opposed to the previous 10 kg per year.

All of the above conclusions are drawn based on the 2003 Commission proposal for the REACH regulation. In the final version the registration requirements of REACH are further reduced as previously mentioned. Many, notably environmental NGOs, have voiced fears that because of these changes REACH will no longer be able to deliver the described benefits (FoEE et al. 2006, WWF 2006). However, no specific attempt is made to adjust the benefit calculations to show the effects of the reduced requirements.

4 Conclusion

The impact assessment of the REACH proposal shows that, although the regulation entails substantial costs, the expected benefits clearly outweigh these and provide for a positive net effect. The difference between the two sides appears to be at least one order of magnitude and large enough for this conclusion to remain valid despite the uncertainties involved in the calculations.

Overall it can be seen that the picture regarding the benefits of REACH is vaguer than that associated with the costs. Some uncertainty is present regarding the indirect impacts of REACH on downstream users and the wider EU economy. Here, the EC's impact assessment is successful in supporting REACH as a proposal that will not entail disastrous economic consequences although it could not completely dispel the fears voiced in some industry studies (see Witmond et al. 2004). Far more uncertainty remains regarding the expected benefits.

As a highly significant piece of legislation, REACH has been subjected to one of the most thorough impact assessments since the introduction of the IIA system. The REACH impact assessment is free from many of the shortcomings found in other assessments that resulted in generally poor evaluations of the EC's impact assessment practices. Following the official impact assessment, the EC also commissioned a number of other studies aimed at clarifying the picture in areas where the original impact assessment offered limited insights. Even so, the REACH impact assessment process completely falls in line with the observation from an American study that "…the typical outcome of a CBA includes a dollar value for expected costs and a wide range of dollar values for a few quantifiable benefits" (Driesen 2005:7).

Furthermore, even these few quantified benefits rely on very general assumptions – such as the 10% reduction in chemical-related damages – with no clear idea about the link between the specific requirements of REACH and the expected benefits. This means that it is not possible to tell how a change in the requirements will affect the positive outcome. The calculation of the direct costs is far more accurate and can be broken down to the level of the prescribed tests – so arguments for dropping any of these can be backed with figures for the costs saved whilst implicitly assuming that the expected benefits will remain unaffected. This could well be the main reason why proponents of a weaker REACH generally gained the upper hand in the negotiations.

Providing stronger arguments for decision-makers has been the main driver behind the development of environmental valuation techniques and the example of REACH also highlights how the lack of sufficiently complete and sound figures, especially when set against such data in the policy debate, can affect the policy outcome. Based on this experience, it seems that the best way to promote environmental interests in decision-making is to improve the quantification of environmental effects and the benefits of environmental regulations in general. However, it is necessary to ask the question as to the extent to which this goal is attainable.

Practice shows that the monetized assessment of environmental, as well as social, effects is always less developed than that of business impacts. There are clear indications from theory showing that this problem is inherent in the nature of environmental goods because ecological systems do not function according to the logic of economic analysis and so can never be fully compensated by improvements in methodology and data collection. Such improvements are of course also unable to resolve the moral issues connected to the monetary valuation of the environment. It seems unlikely that the improvement of impact assessment practices, which is now in the main focus of the EU's efforts on better regulation, can indeed provide a panacea for efficient and effective regulation – at least in the field of the environment.

The example of REACH provides a valuable lesson regarding the results that can be expected from the use of impact assessments in the policy process. It shows that impact assessments can be very useful in a number of ways, such as anticipating the economic burden of a new regulation, helping to clarify a picture which is often distorted by widely diverging claims from various lobbyists, as well as providing some understanding of the benefits, helping to supply arguments in favour of costly environmental policies.

However, the REACH experience also points to the limitations of impact assessments as a tool for choosing the precise course of regulatory action. It supports the suspicion that using impact assessments and cost-benefit analyses to this end does, indeed, favour economic considerations over – always more vaguely presented – environmental interests.

5 Recommendations

In order for impact assessments of environmental regulations to fulfil their desired role as fully reliable and unbiased tools in the policy process, significant development would be necessary in the evaluation of benefits. It should be noted that, while currently much attention is devoted to improving the assessment of environmental effects, most environmental regulations also have potential business benefits whose evaluation seems today to be the least developed, the REACH assessments only go as far as naming expected business benefits. A possible direction for further work would therefore be to strive towards a more meaningful inclusion of these intangible effects in impact assessments.

As discussed above, it is uncertain whether any impact assessment system can indeed ensure the balanced treatment of economic and environmental, social and health effects of regulations. It is therefore vital that, in addition to efforts to improve the quality of impact assessments, policy-makers continue to reflect on the inherent biases and limitations involved and do not disregard effects that are less well represented in the assessments or view impact assessments as the sole basis for the decision-making process.

References

Ackerman F, Heinzerling L and Massey R (2004) *Applying Cost-Benefit to Past Decisions: Was Environmental Protection Ever a Good Idea?* Georgetown Public Law Research Paper No. 576161 Georgetown University

Bolt J, Boon I, Collignon M, van Dijk S, Elting T, van der Kolk J, Luijten J, Ronday R, Stork EJ and Wieling A (2005) *REACH – Further Work on Impact Assessment: A Case Study Approach* Amsterdam, KPMG Business Advisory Services

Cefic (2004) *REACH – Approach of the European Chemical Industry to an Effective New Chemicals Policy for Europe* Brussels, Cefic

ChemSec (2004) *Cry Wolf – Predicted Costs by Industry in the Face of New Regulations* Göteborg, International Chemical Secretariat

Driesen DM (2005) *Is Cost-Benefit Analysis Neutral?* Working Paper Series Syracuse, Syracuse University College of Law

European Commission (2001a) *White Paper – Strategy for a Future Chemicals Policy* COM(2001)88 Brussels, European Commission

European Commission (2001b) *A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development* COM(2001)264 Brussels, European Commission

European Commission (2002) *Communication from the Commission on Impact Assessment* COM(2002)276 Brussels, European Commission

European Commission (2003a) *Proposal for a Regulation of the European Parliament and of the Council Concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), Establishing a European Chemicals Agency and Amending Directive 1999/45/EC and Regulation (EC) {on Persistent Organic Pollutants* COM(2003)644 Brussels, European Commission

European Commission (2003b) *Regulation of the European Parliament and of the Council Concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), Establishing a European Chemicals Agency and Amending Directive 1999/45/EC and Regulation (EC) {on Persistent Organic Pollutants} Extended Impact Assessment* SEC 2003/1171/3 Brussels, European Commission

European Commission (2005a) *Working Together for Growth and Jobs: A New Start for the Lisbon Strategy* COM(2005)24 Brussels, European Commission

European Commission (2005b) *Better Regulation for Growth and Jobs in the European Union* COM(2005)97 Brussels, European Commission

European Commission (2006) *Regulation (EC) No 1907/2006 of the European Parliament and of the Council Concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), Establishing a European Chemicals Agency, Amending Directive 1999/45/EC and Repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC*

European Commission Joint Research Centre, Institute for Prospective Technological Studies (2005) *Implementation of REACH in the New European Member States* [online] [cited 15 July 2008]. Available from Internet URL <http://ec.europa.eu/enterprise/reach/docs/reach/ipts_summary.pdf>

European Parliament (2006) *Parliament Adopts REACH – New EU Chemicals Legislation and New Chemicals Agency* [online] [cited 15 July 2008]. Available from Internet URL <http://www.europarl.europa.eu/sides/getDoc.do?language=EN&type=IM-PRESS&reference=20061213IPR01493>

European Union (2005) *REACH: High Level Group Meets to Assess New Impact Studies* [online] [cited 15 July 2008]. Available from Internet URL <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/05/495&format=HTML&aged=0&language=EN&guiLanguage=en>

FoEE, EEB, Eurocoop, Greenpeace, Health and Environment Alliance, WWF, WECF (2006) *REACH, a Deal Too Far* [online] [cited 15 July 2008]. Available from Internet URL <http://www.chemsec.org/images/stories/news_publications/061201_REACH_deal_NGOs.pdf>

Franz J and Kirkpatrick C (2007) Integrating sustainable development into European policymaking *Journal of Environmental Assessment Policy and Management* 9.2 141–160

Gowdy J and Erickson J (2005) The approach of ecological economics *Cambridge Journal of Economics* 29.2 207–222

Mandelkern Group on Better Regulation (2001) *Final Report* [online] [cited 15 July 2008]. Available from Internet URL <http://ec.europa.eu/governance/impact/docs/key_docs/mandelkern_report_en.pdf>

Martinez-Alier J (1995) Distributional Issues in Ecological Economics *Review of Social Economy* 53.4 511–528

O'Neill J and Spash CL (2000) Conceptions of Value in Environmental Decision-Making *Environmental Values* 9 521–536

Pallemaerts M, Wilkinson D, Bowyer C, Brown J, Farmer A, Farmer M, Herodes M, Hjerp P, Miller C, Monkhouse C, Skinner I, ten Brink P and Adelle C (2006) *Drowning in Process? The Implementation of the EU's 6th Environmental Action Programme* Report for the European Environmental Bureau London, IEEP

Pedersen F, Samsøe-Petersen L, Gustavson K, Höglund L, Koundouri P and Pearce D (2005) *The Impact of REACH on the Environment and Human Health* Report to DG Environment, Hørsholm, DHI Water & Environment

Reihlen A and Lüskow H (2007) *Analysis of Studies Discussing the Benefits of REACH* Institut für Ökologie und Politik GmbH

Renda A (2006) *Impact Assessment in the EU. The State of the Art and the Art of the State* Brussels, Centre for European Policy Studies

Rennie D (2005) 'Most controversial European law' wins parliamentary approval *The Daily Telegraph* 18 November [online] [cited 15 July 2008]. Available from Internet URL <http://www.telegraph.co.uk/news/worldnews/europe/1503325/Most-controversial-European-law-wins-parliamentary-approval.html>

The Evaluation Partnership (2007) *Evaluation of the Commission's Impact Assessment System* Richmond, The Evaluation Partnership Ltd.

Vatn A and Bromley D (1994) Choices without prices without apologies *Journal of Environmental Economics and Management* 26 129–148

Witmond B, Groot S, Groen W, Dönszelmann E (2004) *The Impact of REACH – Overview of 36 Studies* The Hague, ECORYS – OpdenKamp Adviesgroep

WWF (2006) *Briefing on DG ENV Study – Benefits of REACH* [online] [cited 15 July 2008]. Available from Internet URL http://assets.panda.org/downloads/wwf_summary_of_ec_benefit_study_feb_06.pdf

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